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A COMPARISON OF GAINS AND CARCASSES PRODUCED BY THREE TYPES OF FEEDER STEERS[1]

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BEEF type is considered of primary importance by producers. This is amply demonstrated by the attention it receives in our show rings, auctions, and livestock markets. This study is concerned with type as it influences the form of beef cattle rather than the functional types of dairy, dual purpose, and beef cattle.

There have been continuous changes in beef type largely brought about by changing market demands. For many years, selection by the majority of breeders has been for a more compact or "early-maturing" type. This has been justified on the basis that the steers could be finished at an earlier age and lighter weight. In so far as this aim was accomplished, the change seems to have been sound because it was in line with the change in consumer demand. However, claims that compact steers gain more rapidly and efficiently than those of other types do not seem so well founded. Woodward and Clark (1942) report that large type steers gain faster than the smaller type. Stanley and McCall (1945) found height at withers, length of body, and depth of chest to be highly correlated with rate of gain. They also concluded, after comparing nearly 400 steer calves in another study, that the average daily gain of upstanding calves was greater than that of low-set calves. Hultz (1927) likewise reports that very rangy calves make greater and more efficient gains than low-set calves.

Black, Knapp, and Cook (1938) found that among steers of the same weight at the time of slaughter, height at withers and length of body had a negative correlation with rate and efficiency of gain. This indicates that steers which gain more rapidly and efficiently reach a given weight at an earlier age and smaller skeletal size than those that gain more slowly.

Experimental Animals and Procedures

The observations reported here were made on about 350 grade Hereford steers used in feeding experiments from 1937 to 1945 inclusive. These cattle were produced on the experimental ranch of the New Mexico station. The calves were weaned about 12 months before being put on feed and ran together on the range for the intervening time. At the beginning of the experiment the average age was about 19 months, with a variation from 17 to 20 months.

[1] Published with the approval of the Director of the New Mexico Agricultural Experiment Station as paper No. 43 of the Journal series.

When they were brought to the feed lots, the cattle were classified as "compact," "medium," and "rangy" by the visual method. Animals were called "compact" when height and length were small in proportion to depth and width. Differences between the groups were probably minimized by the fact that these steers had all been produced by related dams and sired by 19 bulls, most of which were related. Although differences were not so extreme as might have been obtained from unrelated animals, the similarity in breeding did provide conditions favorable for a study of type relatively uninfluenced by other hereditary factors.

The cattle of each group were divided as evenly as possible between four lots which were fed different experimental rations. At the end of the feeding experiment of 168 days, they were classified again as to type and graded by a committee of animal husbandmen. They were weighed individually and shipped to market, where they were sold with the lots in which they were fed. It would have been desirable to sell each type separately but that was impossible without interfering with the plan of the feeding experiments. Carcass grades were obtained in eight of the nine years and in seven of these years individual carcass weights were obtained from which dressing percentages were calculated. The carcasses were graded by government graders in five of these years and twice by the graders of the packing company to which the cattle were sold.

Results and Discussion

Table 1 contains averages for each of the observations described above. The rangy steers had a significantly greater initial weight, gain, and dressing

TABLE 1. AVERAGE OF NINE YEARS COMPARISON OF THREE TYPES OF STEERS

Items compared	Type		
	Compact	Medium	Rangy
Initial weight, pounds[1]	722	752	785
Gain, pounds[1]	350	360	373
Percent gain[2]	48.5	47.9	47.5
Finished grade[3]	5.3	5.5	5.6
Carcass grade[3]	5.1	5.1	5.1
Dressing percentage[4]	57.4[4]	57.7[4]	58.4[4]

[1] The differences are statistically significant.

[2] Percent gain $= \frac{\text{Gain}}{\text{Initial weight}}$.

[3] The numerical grade of 5 is equivalent to low choice and 6 to high good.

[4] Dressing percentage was calculated by deducting 2½ percent from the hot carcass weight and dividing this by the finished feed lot weight.

percentage. The compact type had a slight non-significant advantage in grade when finished and in gain expressed in percent of the initial weight. The medium type was intermediate in each case. There was no difference between the three types in average carcass grades. The consistency of these results is evidenced by table 2, which gives the rank of the types on each point for each year. It may be noted that where significant differences exist, the rankings were remarkably consistent. The rangy type failed only once in each case to rank first in gain and dressing percentage. There was a slight but not significant tendency for the compact cattle to rank high on percent gain and fat grade. Ranking revealed no more influence of type of feeder steer on carcass grade than the averages shown in table 1.

The fact that the average weight of the rangy steers was greater than that of the compact steers each year was noteworthy but scarcely surprising. Height and length contribute to size. When those dimensions are reduced, weight will decrease if other factors remain unchanged. Differences in the average initial weight of rangy steers over compact steers varied from 25 pounds in 1941–42 to 93 pounds in the last year of the study. The difference in initial weight accounts for the fact that the rangy type made no greater percentage gain in weight than the compact type even though the average gain per head was significantly higher. The expression of gain in percent of the original weight was introduced here because of its bearing on efficiency of gain. Greatest efficiency of gain is often found in cattle making the most rapid gains. This fact was pointed out by Winters (1933) and has been observed by others. Winters recognized, however, the importance of difference in maintenance requirement for animals of varying size. Knapp and Baker (1944) report as the result of a statistical study of records obtained from 66 steers that a high correlation between rate and efficiency of gain is found only among animals of the same size. Guilbert and Gregory (1944) concluded that rate of gain was not closely correlated with efficiency when differences in degree of fatness exist—a fact too often overlooked in comparing the efficiency of beef animals. It appears that with animals as similar in age and in condition, both at the beginning and end of the feeding period, as those used in this study, the percent gain in weight rather than the actual gain is the more reliable indication of efficiency.

The consistency with which the rangy steers out-weighed and gained more than the steers of the other types suggested that gain made in the feed lot may be correlated with the weight of the feeder steers. A statistical study of the data as shown in table 3 corroborated this belief. For each pound of increase in initial weight there was a corresponding increase in feed lot gain of .184 pound, irrespective of type. When all gains were corrected to an average initial weight of 748 pounds, they were found to be 356, 358, and

TABLE 2. RANKING OF TYPES OF FEEDER STEERS

Year	Gain			Percent gain			Finished grade			Carcass grade			Dressing percentage		
	C[1]	M[2]	R[3]	C	M	R	C	M	R	C	M	R	C	M	R
1936–37	3	2	1	1	2	3	3	1 T[4]	1 T	3	2	1	3	1	2
1937–38	2	3	1	2	3	1	1	3	2	1	2	3	2	3	1
1938–39	3	2	1	2	3	1	1	3	2	1	2	3	3	2	1
1939–40	3	1	2	2	1	3	1	2	3	3	2	1	2	3	1
1940–41	2	3	1	2	3	1	1	2 T	2 T	3	1	2	2	3	1
1941–42	3	2	1	2	3	1	1	2	3	—	—	—	—	—	—
1942–43	3	2	1	2	1	3	3	2	1	2 T	2 T	1	—	—	—
1943–44	3	2	1	1	2	3	2	1	3	3	1	2	3	2	1
1944–45	3	2	1	1	2	3	1 T[4]	3	1 T	1	3	2	3	2	1

[1] C = Compact type.
[2] M = Medium type.
[3] R = Rangy type.
[4] "T" indicates a tie.

365 pounds respectively for the compact, medium, and rangy types. These differences are far from significant.

TABLE 3. REGRESSION AND CORRELATION DATA ON INITIAL FEED LOT WEIGHT (x) AND FEED LOT GAIN (y); DATA FROM WITHIN SUBGROUPS

Degrees of freedom	S_x^2	S_{xy}	S_y^2	Regression coefficient	Correlation coefficient
320	1,016,558	187,140	578,848	.184	.244[1]

[1] Correlation coefficient highly significant.

From the foregoing it seems that the greater gains of the rangy cattle were due to size and associated feeding capacity and growth rate rather than to body form.

Dressing percentage was another factor showing a consistent and significant difference, with the rangy type ranking first and the compact type last, although the difference between the compact and medium types was small. This was rather surprising, since it is generally supposed that the compact type would have a slightly higher yield because of less bone and hide in proportion to body weight. The difference observed here was probably due to higher condition or to less paunchiness of the rangy steers. No difference in condition was noted and seems unlikely to have existed because the compact cattle gained as much as the rangy cattle in proportion to their size and should therefore have reached a similar degree of finish. The explanation that the difference was due to paunchiness conforms more closely to observation of the cattle. A compact animal has been described as one in which height and length are small in comparison to depth and width and a rangy animal as one in which the reverse condition exists. Certain animals may have been placed in the compact group by virture of great depth of body while others were classified as rangy because of shallow bodies. It is believed that the presence of a few such steers each year may have caused the relatively small but consistent difference in average dressing percentage.

It was thought that different results might be obtained if the cattle were classified on the basis of their type when finished. This was done with no important change in results although the advantage of the rangy over the compact type in gain and dressing percentage was smaller than when classified on the type of feeder steers. This may be because steers which make good gains frequently appear more blocky at the end than at the beginning of the feeding period while those that make poor gains often appear more rangy.

The effect of sires on the results was another question which appeared to require an answer. The possibility of sires having an important influence on

these data seems small because the get of 19 bulls was used. Except for two bulls which had a very small number of steers in the study, each bull had steers of all three types. In order to check this matter, however, the steers sired by the three bulls with the largest number of offspring in the experiment were compared within their respective sire groups. In each group the rangy steers made a greater average gain than their compact brothers.

Summary and Conclusions

This report covers a study extending over nine years and using about 350 yearling Hereford steers of similar breeding and raised under similar conditions.

Steers classified as rangy when they were put on feed weighed more, gained more, and yielded a higher dressing percentage than the compact steers. The medium type was intermediate in each case. Amount of gain was found to be correlated with the initial weight. When corrected for initial weight, the difference in gain made by steers of the three types was no longer significant although still slightly in favor of the rangy cattle.

There was a slight non-significant advantage for the compact steers when gain was expressed in percent of initial weight. This is interpreted to indicate that there was little or no advantage for the rangy type in economy of gain. Although rate of gain is usually associated with efficiency, under the conditions of this study gain in proportion to initial weight seems to be a better measure of this factor. The rangy steers consistently yielded a higher average dressing percentage than either of the other types. The average carcass grades were the same for each type.

It would appear that type in itself directly affected only size and dressing percentage. The apparent effect on gain was probably due to differences in size. Observations and reports by other workers show that type may affect carcass grade, and sometimes compact steers have had higher dressing percentages than rangy steers. Such results doubtless will be obtained when differences in type are extreme, when the compact type is fatter than the rangy type, or when greater natural thickness is associated with the compact type. The rangy steers used in this study were as thick as the compact steers but differed from them in the proportion of height and length to depth and in size due to greater height and length. Some compact steers make very rapid gains; therefore, it is obvious that some strains of compact cattle may be superior in this respect. From the results of this work, however, it appears that the development of rapidly gaining strains will be more difficult if size is reduced by too greatly restricting height and length to secure compactness.

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THE AMOUNTS OF FEEDS AND NUTRIENTS IN THE RUMEN OF CATTLE THROUGHOUT A 24-HOUR PERIOD AS AFFECTED BY PLANE OF FEEDING AND CHARACTER OF RATION

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RUMEN ingesta studies with steers were conducted in conjunction with digestion and feedlot experiments designed to measure the nutritive value of shelled corn and ground shelled and ground ear corn for fattening cattle. The feedlot and digestion experiments have been reported in part elsewhere, Burroughs *et al.* (1945). The rumen ingesta studies presented in this report were paralleled with the digestion and feedlot experiments for the purposes of correlating differences in the rumen stomach with differences in total feed utilization.

An additional consideration in the present rumen studies pertains to fundamental rumen physiology as it may apply to the digesiton of fibrous feeds and the general nutrition of cattle. Evidence accumulated in recent years points to the importance of the rumen in the digestion of feeds high in cellulose and in the synthesis of essential amino acids and various members of the vitamin B-complex. Since micro-organisms are known to be active agents within the rumen, it is apparent that ration ingredients altering the feed and water content of the rumen may either favorably or unfavorably affect the development or persistence of those organisms.

The purpose of this study was to determine the amounts of feeds and nutrients found in the rumen and reticulum of cattle throughout the day, as they are affected by plane of feeding and character of ration.

Methods

Paunch contents from steers with rumen fistulae were examined at 4-hour intervals over 24-hour periods. Three rations comparing different forms of corn were each fed at three planes of nutrition. The ingesta examinations included total weights of water and dry matter in the rumeno-reticular compartment, as well as the amounts of the principal nutrients, nitrogen-free-extract, crude fiber, protein, ether extract, and ash. The amounts of feeds found in this compartment were computed mathematically from the nutrient ingesta data and checked in part by physical separation methods. These methods were presented in an earlier paper, Burroughs *et al.* (1946).

Similar rations were used except for the form of corn fed (shelled corn, ground shelled corn, and ground ear corn). These rations (table 1) were com-

[1] Resigned February 1944.

pared at a low plane of nutrition similar to that fed steers entering the feedlot, an intermediate plane which was slightly less than a full feed, and a high plane of nutrition similar to that given to cattle which are being finished for market.

TABLE 1. DAILY RATIONS (POUNDS)

Plane of feeding	Feed	Shelled-corn ration	Ground-shelled-corn ration	Ground-ear-corn ration
Low	Corn	2.5	2.5	3.0
	Alfalfa hay (chopped)	3.5	3.5	3.5
	Protein supplement[1]	0.5	0.5	0.5
Medium	Corn	7.5	7.5	9.0
	Alfalfa hay (chopped)	3.5	3.5	3.5
	Protein supplement[1]	1.5	1.5	1.5
High	Corn	10.5	9.5	11.5
	Alfalfa hay (chopped)	3.5	3.5	3.5
	Protein supplement[1]	2.0	2.0	2.0

[1] Protein supplement contained soybean meal 35%, cottonseed meal 35%, tankage 25%, limestone 2%, bonemeal 1% and salt 1%.

Experimental Results

The data presenting the nutrients and feeds found in the rumen ingesta were condensed as much as possible by using average results based, first, upon the plane of nutrition of the steers and, second, upon the type of ration fed. In studying the first criteria average values of 12 determinations at the low plane of feeding, four on each of the three forms of corn fed, were compared with average values similarly obtained at the medium and high levels of feeding. In studying the second criteria average values of 12 determinations using whole shelled corn, four at each of the three planes of nutrition, were compared with average values similarly obtained with the ground-shelled-corn ration and also the ground-ear-corn ration.

Table 2 includes the average weights of rumen nutrients found throughout the day when steers were fed at three different levels of nutrition. In general the water found in the rumen paralleled the level of feeding and the amount of water consumed. The water consumption, as well as the nutrient consumption, can be calculated by subtracting the 8 A.M. and 4 P.M. figures from the respective values listed 30 minutes later at 8.30 A.M. and 4.30 P.M. Of special interest are the relative amounts of rumen water found at various times of the day on the different levels of feeding. At the low level of feeding the maximum amount of liquid was found in the rumen shortly after 8 A.M.

when the steers consumed their entire supply of drinking water for the 24-hour period. The amount of fluid decreased progressively in the rumen throughout the ensuing 24 hours with the exception of the evening feeding period, at which time no drinking water was offered. Slightly more liquid was contained in the rumen a few hours after feeding than before feeding.

TABLE 2. NUTRIENTS FOUND IN RUMEN AND RETICULUM AT DIFFERENT LEVELS OF FEEDING. WEIGHTS ARE IN POUNDS, AND EACH FIGURE IS AN AVERAGE OF 12 DETERMINATIONS,[1] USING TWO STEERS

Time	Water	Dry matter	Nitrogen-free extract	Crude fiber	Protein N×6.25	Ether extract	Ash
Low-level feeding							
8 A.M.	28.29	2.75	0.87	1.00	0.49	0.07	0.31
8:30, feed+water	57.50	5.73	2.53	1.64	0.95	0.15	0.45
12 Noon	51.52	4.36	1.56	1.36	0.82	0.17	0.43
4 P.M.	43.66	3.63	1.24	1.17	0.69	0.13	0.40
4:30, feed	43.66	6.61	2.90	1.82	1.14	0.21	0.54
8 P.M.	46.75	5.29	1.95	1.59	1.03	0.22	0.51
12 Night	41.93	4.11	1.38	1.36	0.80	0.14	0.42
4 A.M.	35.60	3.77	1.27	1.25	0.72	0.12	0.41
8 A.M.	29.69	2.89	0.89	1.04	0.56	0.08	0.33
Medium-level feeding							
8 A.M.	41.54	4.37	1.75	1.11	0.86	0.13	0.53
8:30, feed	47.46	10.15	5.40	1.93	1.73	0.34	0.76
12 Noon	47.65	7.73	3.43	1.67	1.54	0.36	0.72
4 P.M.	41.08	6.55	3.01	1.45	1.26	0.24	0.59
4:30, feed+water	79.91	12.32	6.66	2.27	2.13	0.44	0.82
8 P.M.	62.77	9.90	4.65	2.10	1.93	0.43	0.80
12 Night	54.51	7.97	3.58	1.80	1.56	0.31	0.71
4 A.M.	49.02	6.23	2.67	1.48	1.26	0.21	0.61
8 A.M.	44.35	5.19	2.22	1.25	1.01	0.16	0.56
High-level feeding							
8 A.M.	56.37	7.26	3.16	1.70	1.43	0.20	0.77
8:30, feed+water	77.87	14.35	7.58	2.64	2.59	0.47	1.07
12 Noon	73.64	10.48	4.88	2.15	2.10	0.41	0.94
4 P.M.	60.55	8.66	3.99	1.85	1.72	0.28	0.82
4:30, feed+water	83.01	15.74	8.41	2.78	2.88	0.55	1.12
8 P.M.	75.52	12.11	6.05	2.33	2.37	0.39	0.96
12 Night	65.84	9.61	4.45	2.05	1.96	0.30	0.85
4 A.M.	58.52	8.27	3.78	1.83	1.68	0.23	0.76
8 A.M.	51.97	7.20	3.20	1.63	1.45	0.20	0.71

[1] Corn fed consisted of shelled corn in 4 determinations; ground shelled corn in 4 determinations; and ground ear corn in 4 determinations. All 12 determinations were averaged together as given above.

This is in part the result of the small quantity of moisture in the feeds consumed, but doubtlessly is primarily the result of water gained from an increased flow of saliva into the paunch during mastication.

The maximum amount of fluid in the rumen during the medium level of feeding was found immediately following the evening feed when nearly the entire 24-hour water supply was taken. This high amount of water gradually decreased throughout the ensuing 24-hour period with the exception of the morning feeding period. No decrease was noted at this time which was similar to the condition prevailing at the evening feed when the steers were on the low plane of nutrition.

The water consumption during the high level of feeding was in about equal amounts at the time of the morning and evening feedings. The rumen water likewise reached peaks at these times and decreased thereafter until the following feeding and watering period.

Total dry matter in the rumen was highest following feeding and decreased until the following feeding period. This decrease at the low level of feeding was very constant from period to period. As the plane of nutrition increased the dry matter tended to disappear from the rumen more rapidly shortly after feeding than it did at each succeeding period thereafter. The passage of dry matter out of the rumen followed a more-or-less fixed pattern which appeared to bear little or no relationship to the amount of water in the rumen, except in instances believed largely coincidental. The amount of dry matter found in the rumen preceding feeding was approximately the same amount as that consumed in a feeding period, or one-half the daily ration. This relationship was essentially the same before both the morning and evening feed despite the fact that the interval of time between fedings was twice as long during the night period as that of the day period. Furthermore, the amount of feed in the rumen before feeding was about equal to the amount to be fed whether the amount regularly fed at one time was 3 pounds or twice this amount.

The total protein in the rumen varied with the amount fed or the plane of nutrition. The relationship of pounds of protein found in the rumen prior to feeding as compared with the amount fed, more nearly resembled the above dry matter relationship than was true of any other individual nutrient. The protein appeared to leave the rumen at about the same rate as the dry matter, which meant that the ratio of protein to dry matter in the rumen was approximately the same at one period of the day as compared with most any other. The ratio of protein to dry matter was, however, changed throughout the day when this ratio was changed in the ration.

The total carbohydrate in the rumen at different periods of the day paralleled the amounts of dry matter and protein found in the paunch throughout a 24-hour period. This was not true in the case of the two car-

bohydrate constituents when considered individually as nitrogen-free-extract and crude fiber. At all levels of feeding the nitrogen-free-extract tended to disappear much more promptly after feeding and to reach much lower levels just prior to feeding than did the crude fiber. The rate at which crude fiber disappeared from the rumen was fairly constant following each feeding; however, the rate was faster following the morning feeding period than was the case of the longer period following the evening feed.

The ash content of the rumen ingesta is doubtless of mixed significance. Considerably more ash was found in the ingesta at all levels of feeding than would be expected if it all originated from the feed. Sand particles were readily observable on the floor of the rumen at all times during the collection periods. These particles probably came from soil which the steer consumed sometime previously while in the paddock. Such materials may be retained in the rumen for long periods of time due to the difficulty encountered in transporting heavy materials over the muscular pillars in the bottom of the rumen and in the reticulum.

Another factor contributing to the ash content of the ingesta aside from the food consumed was the ash contained in the saliva entering this compartment. The ash content in the rumen was usually higher a few hours after feeding than would be expected at this time judging from the rate of disappearance of the ash in succeeding periods and also from the rate of disappearance of other nutrients closely associated with the ash. This condition is most readily observed at the lower level of feeding. The phenomenon is believed due to an increased flow of saliva accompanying eating. The saliva ash thus contributing to the total ash in the ingesta.

Considerable difficulty was experienced in determining ether extracts. The significance of this determination for rumen ingesta is questionable. The amounts found in the ingesta on different levels of feeding throughout the day, however, appeared reasonable, with one or two exceptions. At the low and medium planes of nutrition more pounds of ether extracts were found a few hours after feeding than were found in the previous period even after the ether extracts contained in the feed was taken into consideration. This condition might be interpreted as fat synthesis in the rumen; however, a plausible explanation is that organic acids produced by micro-organisms in the rumen were in part extracted by the ether. Anhydrous petroleum ether and alundum thimbles were finally used in all determinations for a 22-hour extraction period. Although this gave better results than ethyl ether, rumen samples at the height of fermentation could be extracted further even after the extraction had continued as long as a week. This was not true of feeds run simultaneously and of ingesta samples which were well past the stage of active fermentation. These latter ingesta samples, however, did take a longer time to extract than did the feed samples.

Feeds in Rumen at Different Levels of Feeding

The estimated feeds in the rumen, as mathematically determined from the rumen nutrients presents an over-all picture of the paunch contents which would otherwise be difficult to comprehend in its entirety. Figure 1 shows graphically the estimated feeds present in the rumen throughout the day at three levels of feeding.

The ratio of corn, hay, and protein supplement as found in the rumen

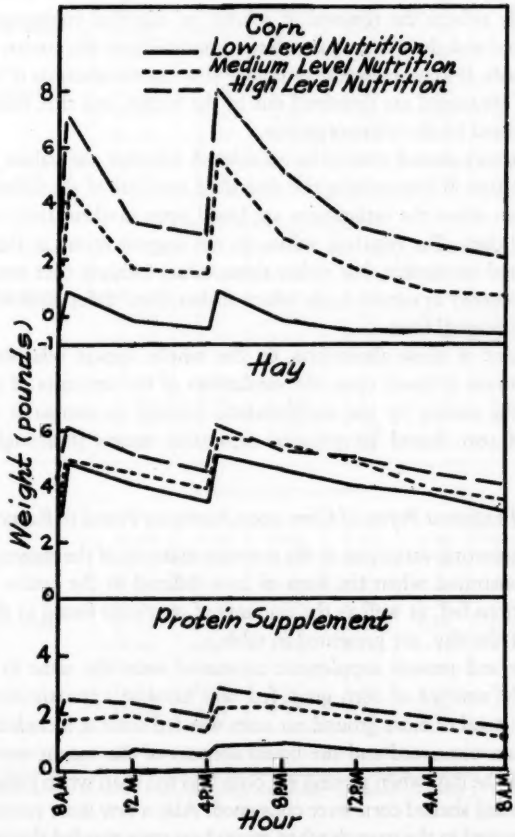

Figure 1. Feeds found in rumen at different levels of nutrition. Each point is based on an average of 12 determinations. Animals were fed and watered at 8:30 A.M. and 4:30 P.M.

did not differ greatly from the proportions of feeds as fed in the different rations. Some differences were, however, apparent; one of which indicated that ground corn appeared to leave the rumen at a somewhat faster rate than did the hay and protein supplement. The hay and the protein supplement, from period to period, were characterized by the constancy with which they left the rumen following feeding. The corn, however, tended to leave the rumen at a faster rate immediately following feeding than was the case at later periods.

The slightly negative values for rumen corn during the low level of feeding probably reflects the removal of soluble or digested constituents from the solid feed and their consequent faster removal from the rumen than the solid materials. It appears logical to assume that certain amounts of nutrients in feeds as consumed are dissolved out in the rumen and that other nutrients are utilized by the micro-organism.

These factors should always be considered whether the values are positive or negative in interpreting the estimated amounts of the different feeds in the rumen when the estimations are based upon mathematical treatment of chemical data. The negative values do not suggest errors in the method of rumen-feed estimation, but rather these values indicate that some alteration has occurred in rumen feeds which makes them differ somewhat from feeds in the original form.

The extent of these alterations, on the whole, appear relatively small. This conclusion is based upon the similarities of the amounts of corn estimated in the rumen by the mathematical method as compared with the amounts of corn found by physical separation means (Burroughs *et al.*, 1946).

Influence of Different Forms of Corn upon Nutrients Found in Rumen

Some interesting variations in the nutrient make-up of the rumen contents were demonstrated when the form of corn differed in the ration fed. The average rations fed, as well as the amounts of nutrients found in the rumen throughout the day, are presented in table 3.

The hay and protein supplement consumed were the same in all three rations. The amount of corn grain fed was likewise approximately equal; however, a total of more ground ear corn was fed since it included the cob.

The water consumed and the liquid content of the rumen were greater throughout the day when ground ear corn was fed than when either shelled corn or ground shelled corn were consumed. Also a few more pounds of dry matter remained in the paunch when ground ear corn was fed than when the other two rations were fed. Rumen protein and ash content were influenced little by ration.

TABLE 3. INFLUENCE OF DIFFERENT FORMS OF CORN UPON NUTRIENTS FOUND IN RUMEN. WEIGHTS ARE IN POUNDS AND EACH FIGURE IS AN AVERAGE OF 12 DETERMINATIONS

Time	Water	Dry matter	Nitrogen-free extract	Crude fiber	Protein N×6.25	Ether extract	Ash
Shelled-corn ration[1]							
8 A.M.	40.71	4.91	2.23	1.08	0.93	0.15	0.51
8:30, feed+water	59.76	10.07	5.43	1.79	1.76	0.36	0.73
12 Noon	56.84	7.53	3.55	1.45	1.48	0.36	0.69
4 P.M.	47.10	6.31	3.06	1.21	1.22	0.25	0.57
4:30, feed+water	62.94	11.48	6.26	1.92	2.05	0.45	0.79
8 P.M.	58.25	9.21	4.75	1.61	1.73	0.40	0.72
12 Night	50.25	7.12	3.45	1.38	1.38	0.30	0.61
4 A.M.	44.44	6.10	2.83	1.27	1.21	0.22	0.56
8 A.M.	38.26	5.15	2.46	1.05	0.99	0.17	0.48
Ground-shelled-corn ration[2]							
8 A.M.	41.10	4.23	1.51	1.18	0.89	0.12	0.54
8:30, feed+water	58.19	9.27	4.61	1.88	1.71	0.31	0.76
12 Noon	54.28	6.71	2.73	1.57	1.44	0.29	0.67
4 P.M.	46.34	5.57	2.15	1.39	1.19	0.21	0.63
4:30, feed+water	67.00	10.61	5.26	2.09	2.01	0.40	0.85
8 P.M.	58.73	7.60	3.07	1.81	1.66	0.33	0.73
12 Night	52.41	6.17	2.35	1.55	1.37	0.24	0.66
4 A.M.	45.36	5.19	1.94	1.36	1.13	0.17	0.59
8 A.M.	40.22	4.45	1.57	1.23	0.97	0.13	0.54
Ground-ear-corn ration[3]							
8 A.M.	44.39	5.24	2.03	1.55	0.97	0.13	0.56
8:30, feed+water	64.89	10.88	5.46	2.54	1.80	0.29	0.79
12 Noon	61.69	8.31	3.59	2.17	1.55	0.29	0.72
4 P.M.	51.84	6.94	3.02	1.87	1.25	0.18	0.61
4:30, feed+water	76.64	12.58	6.45	2.86	2.08	0.34	0.84
8 P.M.	68.06	10.48	4.84	2.59	1.94	0.30	0.82
12 Night	59.52	8.40	3.61	2.28	1.57	0.22	0.72
4 A.M.	53.34	6.99	2.95	1.92	1.31	0.16	0.63
8 A.M.	47.52	5.69	2.27	1.64	1.07	0.13	0.58

[1] Daily ration—shelled corn 6.8 pounds, protein supplement 1.3 pounds, alfalfa hay 3.5 pounds.
[2] Daily ration—ground shelled corn 6.5 pounds, protein supplement 1.3 pounds, alfalfa hay 3.5 pounds.
[3] Daily ration—ground ear corn 7.8 pounds, protein supplement 1.3 pounds, alfalfa hay 3.5 pounds.

Nitrogen-free-extract was considerably higher in the rumen with both the shelled-corn and ground-ear-corn rations than was the case of the ground-shelled-corn ration. Rumen crude fiber was significantly high with ground ear

corn. This higher value no doubt results from the cob present. The ether extract content of the paunch was noticeably high on the shelled-corn ration, due probably to a large number of whole kernels of corn remaining on the floor of the rumen.

The over-all significance of these nutrient differences within the rumen as influenced by ration is graphically illustrated in figure 2 in terms of feeds.

Considerably more corn was carried in the rumen throughout the day

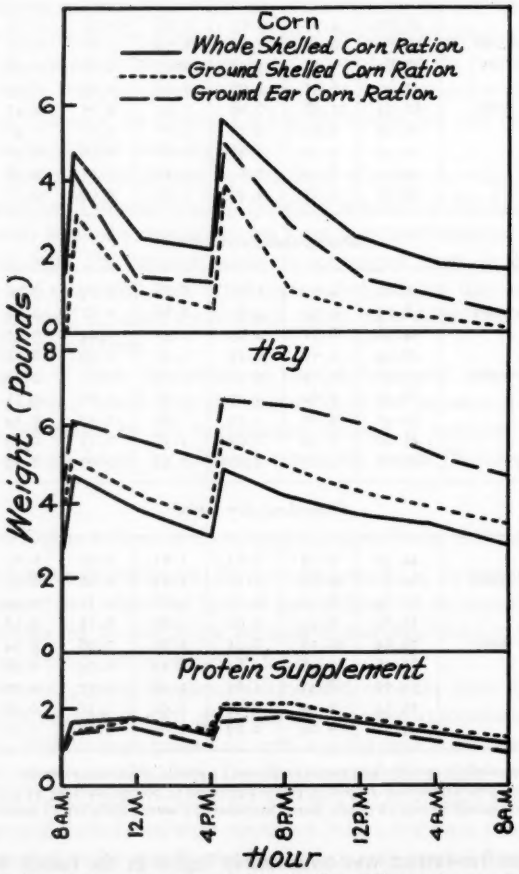

Figure 2. Feeds found in rumen while feeding different forms of corn. Each point is based on an average of 12 determinations. Animals fed and watered at 8:30 A.M. and 4:30 P.M.

when shelled corn was fed than when other forms of corn were consumed. Ground ear corn appeared in larger amounts in the rumen than did ground shelled corn. However, if the weight of the former were reduced to a grain basis by excluding the weight of the cob, this difference would be largely eliminated.

The estimated amount of hay in the rumen was consistently high when the ground-ear-corn ration was fed. Considering the added amount of roughage in the estimated cob in the ground ear corn, the total roughage in the rumen was considerably higher with this ration than was the case with the other two rations. The protein supplement level in the rumen was very similar on each combination of feeds fed.

Discussion

In general the rumen ingesta data are suggestive of certain explanations regarding the over-all nutritive value of different forms of corn for fattening cattle. Total digestion experiments (unpublished data) revealed that ground shelled corn was digested 5 percent more efficiently than was whole shelled corn when fed to steers similar in age and weight to that of the fistula steers. Further study showed this difference to be essentially due to the passage of whole or nearly whole kernels of corn through the digestive tract (approximately 5 percent of the whole corn kernels ingested were recovered in the feces). The ingesta studies when these two forms of corn were fed likewise indicated a similarity in rumen nutrient make-up whose only differences were explainable upon the basis of whole kernels of corn being present in the rumen in the one case and none in the other.

Digestion and feedlot trials, Burroughs *et al.* (1945) have indicated a substantial feeding value in corn cobs when fed in various beef-cattle rations. Appreciable utilization of this feed, high in cellulose and related compounds, necessitates digestion of the type produced by microorganisms such as those living in the rumen of cattle. Certain characteristics of the rumen ingesta were observed in the fistula animals when ground ear corn was fed which may foster conditions desirable for cob digestion.

One such condition was the presence of additional liquid in the rumen when ground ear corn was fed as compared with a lesser amount of water when either whole or ground shelled corn was used in the ration. Additional water may serve either in increasing the size of the rumen or in the degree of dilution of the fermenting material.

Of particular interest was the ability of cobs to soak up large quantities of water. Evidence that cobs imbibe more liquid than do hays can be observed by the relative position which these two feeds occupy in the rumen. Normally, cattle on fullfeed receiving grain and roughage possess a rumen

ingesta mass having a certain degree of stratification despite the constant stirring initiated by the muscular movements of the rumen wall and the locomotion of the animal. The bottom strata contains mud and mineral particles inter-mixed and over-cast with a feed layer consisting principally of grains. Above this strata is a liquid layer containing relatively little solid material. The top portion of the ingesta contains principally hay with occasional entrapped grains. When ground cobs are added to a hay-grain ration they tend to stratify in the water layer of the ingesta beneath that of the hay with some of the heavier cob material mixing with the grain layer and some of the lighter material mixing with the hay strata.

The position which cobs occupy in the rumen may have importance in their micro-biological digestion and/or in their over-all utilization. A noticeable feature observed in the feedlot investigations was that when cattle were fullfed grain and hay, the incorporation of cobs in the grain mixture seldom decreased hay consumption. Despite the resemblance in nutrient and feeding value between cobs and roughages in general, the appetite response of cattle tends to show no such resemblance. This condition might well be due to the different position or behavior of cobs in the rumen as compared with hays.

Significance is placed upon the larger amount and greater concentration of fibrous material in the rumen when ground ear corn was fed than existed when the other two forms of corn were fed. Such a condition in itself would be conducive to greater fiber utilization based upon experiments with sheep (Hamilton, 1942), that fiber is digested to a greater extent when the ratio of fiber to other carbohydrate is increased.

The significance of many of the nutrient relationships which existed in the rumen ingesta cannot be evaluated at this time. Information is needed concerning the rumen conditions favorable to the action of micro-organisms in bringing about fiber digestion and the synthesis of protein and vitamin nutrients. The demonstration of variations in rumen environmental conditions resulting from the feeding of different rations does furnish a basis for future study upon the desirability of such conditions as they may contribute to the utilization of feeds and the nutrition of cattle.

Summary

Rumen contents of steers were examined every 4 hours throughout 24-hour periods for purposes of gathering information pertaining to fundamental rumen physiology in the utilization of feeds by cattle. Two rumen fistula steers were fed successively three rations at three levels of feeding. The composition of the rations differed only in the form of corn used: whole shelled corn, ground shelled corn, and ground ear corn. The rumen ingesta examina-

tions included the weight of the wet material and the following analysis, dry matter, protein, crude fiber, ether extracts, and ash. Estimations of the amounts of feeds existing in the ingesta throughout the day were made by physical separation methods and mathematical determinations based upon nutrient analysis. Only slight differences were noted in the rumen contents when whole shelled corn was compared with ground shelled corn; whereas marked differences in the water and fiber make-up of the rumen existed when ground ear corn was fed. The significance of these differences can be evaluated only in part at present, since information is incomplete concerning conditions favorable to rumen micro-organisms in bringing about fiber digestion and synthesis of protein and vitamin nutrients.

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THIAMINE CONTENT OF RAW AND COOKED PORK TISSUES FROM PIGS OF KNOWN DIETARY HISTORY[1]

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OF THE many references in the literature (Ensminger *et al.*, 1944; Miller *et al.*, 1943; Booher, Hartzler and Hewston, 1942; Hughes, 1941; Pyke, 1940; Waisman and Elvejhem, 1941) which indicate that pork muscle is an excellent source of thiamine, only four give information on the feed the pigs had received. Hughes (1941) reported that the pig is unable to synthesize thiamine and that the amount of this vitamin in pork muscle is related to the amount of thiamine ingested. These findings have been corroborated by Ensminger *et al.* (1944), and by Miller *et al.* (1943), who fed rations containing controlled amounts of thiamine at different levels. Pyke (1940), who tested the thiamine content of various pig muscles using the thiochrome method, found the muscle from "swill-fed" pigs to contain less thiamine than muscle from pigs fed "a normal commercial meal." He concluded that "a good pig ration" supplies all the thiamine that the animal is capable of storing.

It appears that additional data on the thiamine content of pork muscle from pigs of known dietary history are needed.

Around certain of the larger centers of population in the United States, human food wastes may be an important factor in the fattening of hogs. A survey made by Stolting (1941) has indicated that the number of swine annually fed on garbage is probably around one and a quarter million head, and that nearly half of these are fed exclusively on garbage. In the war years, grains became more costly, and with the establishment of the various military posts more garbage has been available for feeding purposes. Especially is this true on the Island of Oahu, in the Hawaiian Islands where relatively large quantities of garbage have always been so used. It is estimated that this material constitutes 75 to 90 percent of the feed during much of the growing and fattening period for most of the pigs marketed on this Island. Feeding practices vary according to the source of the garbage and the age of the pigs. Some pig raisers use grains with the garbage for sows and young pigs only; others use small quantities of grain for all pigs, usually when the garbage appears to be of poor quality.

To add to the knowledge of human nutrition, the thiamine content of animal products produced under diverse conditions and in different areas

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of the United States should be investigated as a corollary of the similar studies now being made on many other foods not of animal origin.

As a contribution to this aim the experiments reported here were planned to compare the thiamine content of pork shoulder muscles from garbage-fed pigs with that of grain-fed pigs, with two commercially canned pork products, and with values given in the literature. Since few data are available (Miller *et al.*, 1943; Booher *et al.*, 1942) on the thiamine content of pork liver, the study was planned to include assays of liver from pigs fed both types of diet.

Experimental

Selection, Care, and Feeding of Experimental Pigs

The pork tissues used in the thiamine assays were obtained from animals that were used in a series of fattening experiments at the University Farm designed to ascertain the concentrate-replacing value of garbage.

All pigs were castrated males except No. 2b which was a female, Pigs

TABLE 1. RATIONS AND WEIGHTS OF PIGS

Pig No.	Average ration fed per pig per day			Period ration fed	Average weights of pigs	
	Concentrate	Garbage	"Koa Haole"		Initial	Final
	pounds	*pounds*	*pounds*	*days*	*pounds*	*pounds*
No. 1a	6.9	—	1.0	86	96	200
1b	6.9	—	1.0	86	94	227
No. 2a	2.2	15.6	1.0	86	71	200
2b	2.2	15.6	1.0	86	88	198
No. 3[1]	6.7	—	1.0	71	103	197
No. 4[1]	3.3	14.5	1.0	71	96	230

[1] Pigs 3 and 4 were animals used in trial 2 of the feeding experiment to determine the concentrate replacing value of garbage.

numbered 1a, 1b, and 2a were pure Berkshires, Nos. 2b, 3, and 4 were Tamworth-Berkshire crossbreds.

From weaning until the beginning of the fattening experiment, the pigs were given what was considered a good pig ration containing a mixture of grains, and fish meal or tankage, such as is commonly recommended for young pigs.

Data on the quantities of the rations fed, the period of feeding, and the weights of the pigs at the beginning and end of the fattening experiments are given in table 1.

During the fattening experiment four pigs were housed together. A green legume feed, "Koa haole" (*Leucaena glauca*) was fed at the rate of one pound daily to each pig. The main feed stuff of pigs 1a, 1b, and 3 was a mixed concentrate as follows: 64 pounds steamed rolled barley, 20 pounds cane molasses, 7 pounds tankage, 7 pounds soybean oil meal, 1 pound each of steamed bonemeal and salt. Pigs 2a, 2b, and 4 received the same quantity and kind of green feed stuff and a small amount of concentrate as shown in table 1. However, the principal food of pigs 2a and 2b was garbage obtained from the University Cafeteria, that of No. 4 was garbage from a military cafeteria. In this paper the pigs receiving only the concentrate are referred to as "grain fed" and those receiving some grain but mainly garbage as "garbage fed."

Pigs numbered 1a, 1b, 2a, and 2b were slaughtered at approximately 7½ months of age after 86 days on the experimental diet, and Nos. 3 and 4 at about 6 months of age after 71 days on the experimental diet (table 1). They were killed at a local slaughter-house about 1:00 A.M. The livers and shoulders were obtained from the wholesaler before noon of the same day.

Chemical Analyses of Feeds and Meat

The methods used in all chemical analyses were those recommended by the Association of Official Agricultural Chemists (1940).

Chemical analyses of five composite samples of garbage showed it to contain an average of 29.1 percent dry matter, 20.8 percent of protein, 32.6 percent of ether extract, 2.3 percent crude fiber, 3.5 percent ash and 40.7 percent N-free extract. Analyses of two composite samples of the concentrate mixture showed it to contain an average of 84.6 percent dry matter, 15.2 percent of protein, 2 percent ether extract, 4.9 percent crude fiber, 67.7 percent N-free matter, and 10.2 percent ash.

All pork shoulder samples, and the canned products, were analyzed for moisture, fat, and protein (table 2). Only the protein is reported for the liver samples.

Preparation of the Samples for Vitamin Assay

Equal quantities of cooked liver from the grain-fed pigs 1a and 1b were combined, ground and mixed (Liver 1, cooked, table 3). Equal quantities of liver from the garbage-fed pigs 2a and 2b were combined. One-half of this composite sample was ground and mixed in the raw state (Liver 2, raw, table 3), the other half was cooked, ground and mixed (Liver 2, cooked, table 3). Slices of liver about one-half inch thick were fried in deep fat (mixed vegetable oils and fats) for 5 minutes at a temperature of about 350° F. (about 177° C.).

The pork shoulders were cuts as commonly made in Hawaii and varied in

weight from 6.5 to 9.5 pounds. One shoulder each from grain-fed pigs Nos. 1a and 1b was freed of all visible fat in the raw state. Equal quantities of a composite of all the lean meat from each shoulder were combined, ground, and thoroughly mixed (Pork shoulder 1, raw, table 3). The other shoulders were roasted in electric ovens at a temperature of 350° F. (about 177° C.)

TABLE 2. COMPOSITION OF PORK TISSUES

Sample	Moisture	Fat	Protein (N×6.25)
	percent	*percent*	*percent*
Liver[1]			
No. 1 Cooked			33.7
No. 2. Raw			22.5
No. 2. Cooked			38.4
Pork shoulder[1]			
No. 1. Raw	73.6	4.5	21.0
No. 1. Cooked	59.4	10.9	28.9
No. 2. Cooked	62.0	8.3	29.2
No. 3. Cooked	58.0	11.0	30.3
No. 4. Cooked	58.5	11.3	29.6
Canned pork, commercial			
No. 5	48.6	22.5	17.7
No. 6	50.2	23.8	17.6

[1] Samples numbered 1 and 3 were from grain-fed pigs, Samples 2 and 4 from garbage-fed pigs.

until the inserted meat thermometers registered a temperature of 185° F. (85° C.). In each case this required approximately 3 hours (average for roasts—3 hours and 10 minutes.). No water or salt was added during the cooking. The shoulders were cooled and stored overnight in an electric refrigerator at about 40° F. For cooked samples No. 1 and No. 2 equal quantities of a composite of all the lean pork freed of visible fat were combined from each of two shoulders, mixed, ground, and stored as for the raw pork. Samples 3 and 4 each represented all the lean meat from a single shoulder prepared as were the other samples.

All samples were stored in glass bottles in the freezing units of gas or electric refrigerators.

Two brands of commercially canned pork were also tested for thiamine. According to the labels on the cans, sample No. 5 was ground pork shoulder meat with ham meat added and salt, sugar, sodium nitrite and flavoring, and No. 6 was chopped ham, salt, sugar, sodium nitrate and sodium nitrite. New cans purchased at different retail markets were opened each week. The

meat was removed from the cans and stored in glass under the freezing unit of the refrigerator.

Biological Tests

A sufficient number of rats were not available at one time to assay the thiamine content in both the raw and cooked conditions of each kind of meat from the two lots of pigs. Consequently, as shown in table 3 series I,

TABLE 3. SUMMARY OF THE RESULTS OF FEEDING PORK TISSUES TO RATS AS THE SOLE SOURCE OF THIAMINE

Supplements	Amount fed daily	No. of animals	Average weights			Mean gain in 3 weeks	Thiamine per 100 gms.
			at start	at depletion	final		
	gm.		gm.	gm.	gm.	gm.	micro-grams
Series I (after 1st depletion of thiamine stores)							
Negative Control	0.0	13	41	65	49	−16	—
Thiamine	3μg.	14	42	68	99	31±1.4	—
Liver[1] 1, (cooked)	1	12	42	67	102	35±2.7	348
Liver[1] 3, (raw)	0.7	13	42	69	84	15±1.9	237
Liver 3, (cooked)	1	13	42	69	87	18±2.1	188
Series II (After 2nd depletion of thiamine stores)							
Thiamine	4μg.	12	97	93	137	44±4.5	—
Pork shoulder[1] 1, (raw)	0.5	12	98	93	140	47±3.9	865
Pork shoulder[1] 1, (cooked)	0.8	11	96	92	135	43±4.0	488
Pork shoulder[1] 2, (cooked)	0.8	11	90	87	116	29±3.4	338
Series III (After 1st depletion of thiamine stores)							
Negative Control	0	9	39	63	45	−18	—
Thiamine	3μg.	13	40	63	100	37±2.2	—
Pork shoulder[1] 3, (cooked)	0.5	13	39	63	96	33±1.2	520
Pork shoulder[1] 4, (cooked)	0.7	13	38	64	95	31±2.2	343
Canned pork, commercial							
Sample No. 5	0.5	11	38	62	89	27±2.4	400
Sample No. 6	0.5	12	38	63	86	23±2.5	350

[1] Samples numbered 1 and 3 were from grain-fed pigs, samples 2 and 4 from garbage-fed pigs.

the liver from the grain-fed pigs was given to the rats in the cooked form, while that from the garbage-fed pigs was assayed both raw and cooked. In series II, shoulder muscles from grain-fed pigs were fed to the rats in both the raw and the cooked states. All other thiamine determinations on shoulder muscles from both lots of pigs were obtained from the cooked material only.

The thiamine values were determined by the biological method described

by Miller (1943). The larger samples were fed 6 times and the smaller samples, 3 times a week. The final results of the feeding experiments are summarized in table 3.

The quantities of raw and cooked lean pork shoulder fed in series I, were so large that the weight gains of the rats (data not included to save space) were beyond the accurate portion of the curve of response, therefore, the feeding tests were repeated in series II. Because the thiamine values for raw and cooked lean pork muscle were smaller than those reported in the literature, it was thought there might have been some destruction of thiamine due to the long period of storage and the fact that the frozen samples were once slightly thawed because of failure of the refrigerating system. Also the standard errors of the mean gains show that the growth responses were much less uniform than usual after a second depletion of thiamine stores, although the "t" values indicate the results to be highly significant. However, a third series of feeding experiments using a fresh source of cooked pork muscle (samples 3 and 4, table 3) yielded values within 10 percent of those in series II.

Results and Discussion

Pork liver lost approximately 40 percent in weight as a result of frying The data for raw and cooked liver No. 2 indicate that approximately 52 percent of the thiamine was destroyed as a result of cooking. According to the experiment, cooked pork liver No. 1 from grain-fed pigs contained approximately 85 percent more thiamine than cooked pork liver No. 2 from garbage-fed pigs.

The lean portion of the shoulders trimmed free of visible fat constituted 35 to 40 percent of the raw weight and 50 to 55 percent of the cooked weight.

On the basis of cooked and uncooked weights for the whole shoulders the loss in weight as a result of cooking was from 25 to 30 percent. It is impossible to determine the weight lost by the lean portion only but assuming that it is about 27 percent and using the thiamine values for sample No. 1 in the raw and in the cooked states, it may be calculated that the loss due to cooking is about 59 percent. If the thiamine values of the protein portion of the raw and cooked samples are calculated and compared, the loss in thiamine which resulted from cooking also appears to be nearly 59 percent. This relatively large loss may be the result of the cooking period of more than 3 hours which was required to bring the interior of the roasts to a temperature of 185° F. The destruction of thiamine in fresh pork roasts reported in the literature (Booher *et al.*, 1942; Waisman and Elvejhem, 1941) seems to have been determined only on pork loins which were cooked a much shorter period.

The findings here reported suggest that a difference may exist in the original thiamine content of pork shoulder and loin.

A comparison of the thiamine values for the cooked pork shoulder samples (No. 1 with No. 2 and No. 3 with No. 4, table 3) indicates that the lean meat from grain-fed pigs contains approximately 47 percent more thiamine than that from garbage-fed pigs.

The values of 400 micrograms and 350 micrograms per 100 grams for the two commercial samples of canned pork are somewhat less than those reported for similar products by the Bureau of Home Economics, U. S. Department of Agriculture (Booher *et al.*, 1942). The values for the commercial samples are equal to or greater than the values determined for lean pork shoulder from grain-fed pigs, when the protein and fat contents of the commercial samplers are considered.

The thiamine values for raw and cooked lean pork given here (table 3) are lower than most of those reported in the literature (Booher *et al.*, 1942; Pyke, 1940; Waisman and Elvejhem, 1941). If the thiamine content of pork tissues is dependent upon the thiamine content of the rations fed the pigs then it is obvious that even our grain-fed pigs must have received less thiamine than most of the pigs whose tissues have been assayed by others. From the standpoint of human nutrition, the importance of the work here reported lies in the finding that when the ration of the hog largely consists of garbage throughout the entire fattening period, the recognized value of pork muscle as a good source of thiamine may be considerably reduced. In addition, data are needed to show how long a time it is necessary to feed gains or some other good source of thiamine after a period of garbage feeding in order to bring the thiamine content of pork muscle to a maximum. This experiment is being repeated in much greater detail and the preliminary results are in line with those here reported.

Summary and Conclusions

Pork tissues (raw and cooked) from pigs fed garbage and from pigs fed a concentrate mixture were assayed for thiamine by the rat growth method. Two commercially canned ground pork products were also tested. Samples fed were analyzed for moisture, fat and protein.

According to the experiments herein reported it was found that:

1. Slices of pork liver fried in deep fat at 350° F. (about 177° C.) for 5 minutes lost 52 percent of their original thiamine content. There was a loss of nearly 59 percent of the thiamine in lean pork muscles when pork shoulders weighing 6.5 to 9.5 pounds were roasted for about 3 hours at an oven temperature of 350° F. (about 177° C.).
2. Cooked pork liver from grain-fed pigs contained 348 micrograms thiamine per 100 grams or about 85 percent more of the vitamin than the 138

micrograms thiamine per 100 grams in the cooked livers of garbage-fed pigs.

3. The 500 micrograms thiamine per 100 grams of cooked lean shoulder muscles from grain-fed pigs was about 47 percent greater than the 340 micrograms thiamine per 100 grams of cooked lean shoulder muscles from garbage-fed pigs.
4. Two commercially canned ground pork products compared favorably with the grain-fed samples when the higher fat contents of the former were considered.

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CONTROL OF RANCIDITY IN SOYBEAN-FED PORK[1]

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SALTED meats have a marked tendency to become rancid, particularly when these meats are stored at high temperatures. This rancidity, in the early stages, is primarily a surface phenomenon and can be detected by the sharp odor which develops in the fatty tissue. With prolonged storage rancidity may proceed to such an extent that palatability is greatly reduced and eventually the meat is rendered inedible. Thus, it can be seen that the development of rancidity in cured pork and especially bacon is of considerable importance to all who cure meat to be stored for later use.

Storage conditions are not the sole factors responsible for the rapidity with which rancidity may proceed. The firmness or saturation of the pork fat is directly related to its stability. Thus, the softer or more unsaturated fats have a shorter induction period or rancid-free life. The firmness of the fat is largely dependent on the composition of the ration which the hog is fed. Carbohydrate feeds will produce firm fat while feeds with high oil content such as soybeans and peanuts will produce soft and oily pork.

The large acreage of soybeans grown in several sections of the country, and the high quality protein of the soybean insures that rather large amounts of these beans will be fed to hogs. It is well to note that hogs are commonly grazed on fields where only the beans missed in harvesting are available. Thus, the low cost of the gains may justify the production of a soft or oily pork. This being the case it is desirable to have materials available which can be used to stabilize the cured meats produced from these carcasses.

Information is thus needed regarding both the effects of various feeding procedures and the control measures. The investigations reported here are a part of extensive research undertaken to find improved methods for controlling the development of rancidity in cured pork, which would increase the value of these cured cuts by preventing waste and improving palatability. The control of rancidity may also improve the nutritive value of the meat by preventing the destruction of essential fatty acids and other dietary nutrients such as the vitamins.

Hostetler and co-workers (1939, 1940) have shown that there is a high

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correlation between the degree of firmness of the pork carcass and the oil content of the ration. Ellis and Isbell (1926) also report that the oil composition in the ration has a marked effect on the composition of the fat in the carcass. When hogs were fed peanuts and soybeans the composition of the pork fat was similar to the oils in these feeds particularly from the standpoint of the amount of saturated and unsatuated fatty acids present. The iodine number and the refractive index were found to be the best indicators of the degree of firmness of the fat. White (1941, 1941a), in studying the factors affecting rancidity, found considerable variation in stability from carcass to carcass. Of the several methods used to measure rancidity the peroxide values were most reliable. Fiero (1940), in a study of the suitability of various hydrogenated oils as ointment bases, found that rancidity development was correlated with the iodine number. Samples having a high iodine number were more subject to rancidity development. Helser and co-workers (1939, 1940), in a study of lard produced from pigs fed varying amounts of soybeans, found peroxide values of lard stored six months increased as the amount of soybeans in the ration increased. Vestal and Shrewsbury (1932) found that raw and cooked soybeans when fed in limited amounts had a softening effect on the carcass of the hog, but that the quality of the cured and smoked hams and bacon was satisfactory from the commercial standpoint.

Lundberg *et al.* (1944) have shown that with lard, nordihydroguaiaretic acid (N.D.G.A.) has powerful antioxidant properties which are enhanced when used in combination with ascorbic acid. Mattill (1931), French *et al.* (1935), Olcott and Mattill (1936), Olcott and Emerson (1937), and Golumbic and Mattill (1942), have made extensive investigations on the chemical characteristics of antioxidants. They determined oxygenic indices of many antioxidants and demonstrated that lard can be stabilzed with these materials. Smith, Brady, and Comstock (1945) found nordihydroguaiaretic acid (N.D.G.A.), d-isoascorbyl palmitate, soybean lecithin and mixed tocopherols, and five different concentrations of gossypol were all effective in retarding rancidity development in cured bacon.

Procedures

To produce pork carcasses which vary over a rather wide range in degrees of fat firmness, 20 pigs were divided into 5 groups to be fed rations suitable for producing the desired distribution. The grouping had no other significance in the design of this experiment than to obtain this variability. Four of the pigs (group A) were fed on firm fat producing rations from weaning until the time they were slaughtered. Sixteen of the pigs (groups B, C, D, and E) were fed rations with high oil content from weaning time. Groups

B, C, and D were then changed to and finished on a firm fat producing ration at various weight periods as indicated in table 1.

The hogs were slaughtered at an average weight of 182 pounds. The bacon was dry cured 9 days in a mixture of 5 pounds of salt, 2 pounds of sugar, and

TABLE 1. RATIONS[1] FED DURING VARIOUS AVERAGE WEIGHT PERIODS

Group	Weight in pounds				
	Weaning—99	99–114.5	114.5–126.75	126.75–149.25	149.25–182.25
A	Ration 1	Ration 4 →			
B	Ration 2	Ration 3 →	Ration 4 →		
C	Ration 2	Ration 3 →		Ration 4 →	
D	Ration 2	Ration 3 →			Ration 4 →
E	Ration 2	Ration 3 →			

[1] Ration 1—A growing ration with no soybeans.
Ration 2—A growing ration consisting of 98 percent ground soybeans.
Ration 3—A fattening ration consisting of the following percentage composition: ground soybeans, 65; corn, 24; tankage, 2.0; mineral, 1.5; ground legume hay, 7.5.
Ration 4—A fattening ration consisting of the following percentage composition: ground corn, 80; cottonseed oil meal, 5.0; tankage, 6.0; mineral, 1.5; ground legume hay, 7.5.

2 ounces of saltpeter per hundred pounds of meat. After curing the bacon was soaked 30 minutes and dried overnight at 36° F. The bacon was not smoked.

The bacon was sliced five millimeters in thickness prior to treating with antioxidants. The four treatments consisted of a check, nordihydroguaiaretic acid (N.D.G.A.), unrefined soybean oil, and unrefined (expeller process) cottonseed oil. These four treatments were assigned completely at random as to carcass, left and right sides, and location of the slice within the side. Method for treating the slices and making peroxide determinations were the same as previously described (Smith, Brady, and Comstock, 1945) except the slices were heated in the oven at 75° C for 2 hours instead of 3 hours. Iodine absorption numbers and refractive indices were taken to determine the initial values of each slab before receiving treatment. The iodine absorption numbers were determined by the Hanus Method (A.O.A.C., 1940). The refractive indices were determined with the Abbé Refractometer (A.O.A.C., 1940).

Results

The principal information from this experiment was obtained by analyzing 80 regression coefficients of peroxide number on time, one from each carcass for each treatment. These values together with the iodine number, refractive index and carcass grade are given in table 2. The regression

TABLE 2. FAT CHARACTERISTICS AND REGRESSION COEFFICIENTS[1]

Group No.	Carcass No.	Iodine No.	Refractive index	Carcass grades	Daily rate of change in peroxide values[2]				
					Check	N.D.G.A.	Soybean oil	Cottonseed oil	Average
A	3	61.7	1.4594	Hard	5.45	1.90	.53	.22	2.02
	5	59.9	1.4592	"	4.80	1.80	1.22	.39	2.05
	15	68.5	1.4603	"	5.20	1.79	.83	.53	2.09
	20	60.7	1.4595	"	6.10	1.61	.77	.29	2.19
Average		62.7	1.4596		5.39	1.78	.84	.36	2.09
B	1	78.3	1.4615	Med. hard	2.61	1.66	.86	.41	1.38
	4	75.5	1.4610	" "	4.76	2.11	.56	.74	2.04
	8	67.8	1.4604	" "	5.39	2.29	1.70	1.15	2.63
	10	70.5	1.4608	" "	6.52	2.70	2.65	1.26	3.28
Average		73.0	1.4609		4.82	2.19	1.44	.89	2.33
C	7	79.7	1.4618	Med. soft	6.18	2.33	2.23	1.52	3.07
	12	81.4	1.4620	Soft	7.52	2.69	2.57	.98	3.44
	16	88.9	1.4630	Very soft	6.35	3.35	3.16	2.02	3.72
	19	90.0	1.4634	Med. soft	7.44	2.58	2.50	1.44	3.49
Average		85.0	1.4626		6.87	2.74	2.62	1.49	3.43
D	2	92.5	1.4636	Soft	9.54	3.09	4.19	2.57	4.85
	11	99.0	1.4646	Very soft	6.94	3.40	3.05	1.18	3.64
	14	98.1	1.4645	" "	5.80	3.55	4.50	1.54	3.85
	18	95.0	1.4639	" "	7.84	2.24	2.49	1.73	3.57
Average		96.2	1.4642		7.53	3.07	3.56	1.76	3.98
E	6	97.9	1.4640	Very soft	6.37	3.85	4.68	1.26	4.04
	9	99.4	1.4647	Oily	6.25	3.88	3.45	1.72	3.82
	13	95.8	1.4641	Oily	6.27	3.31	3.94	1.39	3.73
	17	97.8	1.4648	Oily	8.63	3.34	3.72	2.59	4.57
Average		97.7	1.4644		6.88	3.60	3.95	1.75	4.04
Averages for all carcasses		82.9	1.4629		6.30	2.67	2.48	1.25	3.97

[1] Treatment—Least Significant Difference at .05 level = .4560; .01 level = .6065.
Carcass—Least Significant Difference at .05 level = 1.0200; .01 level = 1.3566

[2] Milliequivalents of peroxide per kilogram of fat.

coefficients or slopes are rates of change in peroxides; for example, with carcass number 1, check, the peroxide value increased an average of 2.61 milliequivalents per kilogram each day. The coefficients are calculated on the linear portion of the curve. Only this portion of the curve was considered since it includes the practical range which is pertinent to this experiment. The extremely high peroxide values in the curvilinear portion have little or no significance in interpreting the results since the samples were very rancid at lower peroxide values. Figure 1 illustrates the effect of antioxidants on the

rancidity development of sliced bacon from 3 of the groups, A, C, and E.

The analyses of variance showed highly significant differences between the four treatments and between various carcasses. The differences found between the carcasses reflected differences in the amount of soybeans fed. Significant interactions were also found between treatments and carcasses.

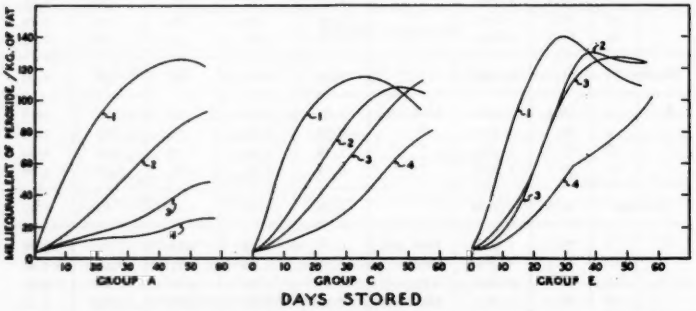

Figure 1. Effect of Antioxidants on Rancidity Development in Sliced Bacon. 1. Check group. 2. Nordihydroguaiaetic acid (N.D.G.A.). 3. Unrefined soybean oil. 4. Unrefined (expeller process) cottonseed oil.

Analyses of the regression of 20 carcass slopes on the iodine number and the refractive index were made on the total of the four treatments and on each treatment separately. These analyses indicated that the two fat constants were essentially measuring the same fat characteristic as far as their relationship to the peroxide values were concerned. Therefore, only one, the refractive index, was used in the analyses involving differences among treatment slopes. In table 3 are given the regression coefficients together

TABLE 3. RELATIONSHIP BETWEEN REFRACTIVE INDEX AND PEROXIDE VALUES

Treatment	Change in rate of increase in peroxide values per 0.001 change in refractive index[1]	Percent of variation accounted for by the refractive index
Check	.413	29 percent
Nordihydroguaiaretic acid	.326	72 "
Unrefined soybean oil	.592	72 "
Unrefined cottonseed oil	.272	59 "
Average of all treatments	.401	68 "

[1] Least significant difference—.05 level = .229; .01 level = .305.

with the percentage of the variation which may be accounted for by the refractive index. Thus, in the average for all treatments, 68 percent of the variation in the regression coefficients can be accounted for by the refractive index, and the higher the index the more rapid the rate of peroxide development. The regression value of .401 indicates that for each increase of .001 in refractive index there was an increase of .401 in the rate of peroxide formation.

The results of this experiment are in agreement with the results published by Hostetler and co-workers (1939, 1940) and Ellis and Isbell (1926) on the effect of oily feeds on the deposition of unsaturated fat in the pork carcass. Likewise, they are in agreement with Fiero (1940) on the relationship between iodine number and rancidity development. The marked increase in the rate of slope with decreasing fat hardness or increasing unsaturation is readily apparent. Likewise, the decreasing efficiency, although not uniformly so, of the various antioxidants with increasing unsaturation can be seen. For although on an average the slopes for nordihydroguaiaretic acid (N.D.G.A.) and soybean oil are the same, nevertheless, their changes in slopes differed significantly, .326 and .592. This indicates that while soybean oil was less effective than N.D.G.A. in controlling rancidity of the more saturated pork fat it became comparatively more effective as unsaturation increased. While all the antioxidants were effective in retarding rancidity development unrefined cottonseed oil was by far the most effective.

Summary

By varying the amount of soybeans as well as restricting the periods in which it was fed it was possible to produce pork carcasses of varying firmness of fat. The iodine number and refractive index both satisfactorily measured the firmness or saturation of the fat. Susceptibility to rancidity development as measured by the peroxide test was found to be correlated equally well with both the iodine number and the refractive index.

Crude expeller process cottonseed oil was found to be superior to N.D.G.A. and crude soybean oil as an antioxidant. The comparative effectiveness of the soybean oil and N.D.G.A. was found to vary with the degree of saturation. All three of the antioxidants were more effective in retarding rancidity development than the control. The antioxidants were most effective in delaying the induction period with the more saturated fat.

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THE EFFECT OF INTAKE OF GARBAGE FAT UPON FAT CONTENT OF SOW'S MILK[1]

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Introduction

MANY studies have been made with dairy cows to determine the effect of the fat content of the ration upon the fat content of milk. The literature has been reviewed by Expe (1941) and Morrison (1936). The authors of the present paper were unable to find in the literature any similar studies with swine. The work with sows has been largely limited to the determination of the general composition of the milk with little attention being given to the effect of nutrition or other factors. This subject has been reviewed by Smith (1937).

At the Hawaii Agricultural Experiment Station considerable work has been done in determining the nutritive value of garbage from military camps. In one project with brood sows different proportions of garbage and a dry concentrate mixture were compared in relation to the growth and mortality of suckling pigs. Since the garbage was much higher in fat, milk samples were collected from the sows to determine if there were any differences in fat content of the milk. The problem was suggested by the reports of various pig raisers who claimed that diarrhea was prevalent among pigs nursing sows which were receiving nothing but garbage and green grass. In their estimation this condition was caused by the milk being too "rich." This paper reports the results of the study.

Procedure

Eighteen sows of four breeds were used. They were fed three rations as follows: (1) garbage only, (2) two parts garbage and one part dry concentrate, and (3) dry concentrate only. In the second ration approximately one-half of the total digestible nutrients was obtained from the garbage. The dry concentrate mixture consisted of barley, 66 percent; cane molasses, 10; finely ground pineapple bran, 5; meat and bone meal, 9; soybean oil meal, 9; and salt, 1 percent. The sows also received green grass daily. The proximate analysis of the concentrate mixture computed by use of Morrison's (1936) tables is given in table 1. The chemical composition of the garbage, on the same dry-matter basis as the dry-concentrate mixture, is also presented in the table. The analysis of the garbage was determined by analyses of monthly

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composites during the time these fat studies were made. It contained 70.7 percent water as fed. The amounts of the different rations fed were adjusted to supply equal amounts of total digestible nutrients, and the amount of total digestible nutrients supplied varied with the size and maturity of the sows and the size of the litters.

TABLE 1. CHEMICAL COMPOSITION, ON AN AIR-DRY, EQUAL-MOISTURE, BASIS OF THE GARBAGE AND OF THE DRY-CONCENTRATE MIXTURE FED THE SOWS

Components	Garbage	Dry-concentrate mixture
	percent	*percent*
Moisture	10.5	10.5
Total crude protein	17.1	14.6
Ether extract	27.1	2.8
Crude fiber	1.7	5.2
Nitrogen-free extract	39.1	60.6
Ash	4.5	6.3

The procedure followed in obtaining milk from a sow was as follows: The suckling pigs were removed from the pen. After one or two hours all but one, two or three, depending upon the size of the litter, were placed back with the sow. While the pigs were nursing, one or two people each stroked an unclaimed teat until milk ejection took place. It was necessary to have part of the litter nurse the mother at this time in order to bring about the stimulation required for milk ejection. If two people were working together their samples were combined.

The fat in the milk was determined with the Babcock tester. Since the samples were smaller than the standard 17.5 cc. volume, the fat readings on the testing bottles were corrected by means of the following formula:

$$\text{Fat percentage} = [\text{Fat as read} - (0.1 - \frac{0.1\ (\text{Size of sample})}{17.5})] \frac{17.5}{\text{Size of sample}}.$$

This formula corrects for the fat remaining in the milk-serum and acid mixture below the fat column after centrifuging. Van Slyke (1927) states that with a 17.5 cc. sample this amount varies from 0.1 to 0.2 cc. and is compensated for by reading to the top of the meniscus in the neck of the bottle. As shown below, the use of 0.1 cc. gave an accurate correction. This formula also corrects for the size of sample put into the Babcock testing bottle.

To test the accuracy of this method in measuring the fat in milk, samples from eighteen cows were used at one time. From each cow volumes of 17.5

cc. and 4.0 cc., each in duplicate, were placed in test bottles. Acid was added in proportion to the milk. A second set of 17.5 cc. and 9.0 cc. samples from different cows was likewise tested. In both cases the test bottles were numbered at random and scattered throughout the centrifuge in order that the individual making the readings would have no bias. The average fat tests are presented in table 2.

TABLE 2. COMPARISON OF FAT PERCENTAGES WHEN 17.5 CC., 9.0 CC., AND 4.0 CC. VOLUMES OF COWS' MILK WERE TESTED IN THE BABCOCK TESTER. THE PERCENTAGE FIGURES FOR THE SMALL SAMPLES HAVE BEEN CORRECTED

Items compared	First trial		Second trial	
Duplicate pairs (No.)	18	18	18	18
Volume of milk in each test bottle (cc.)	17.5	4.0	17.5	9.0
Fat (percent)	3.38	3.37	3.20	3.22

By an inspection of table 2 it can be seen that, by making the corrections as described above, there was no systematic error caused by the use of the small samples. A statistical analysis of the data showed that with this method of fat analysis there was an increase in experimental error as the size of samples was reduced below 9 cc. The method was sufficiently accurate, however, to measure the differences observed in the sows' milk.

After a few milk samples were collected from the sows and the fat contents determined, it was observed that the amount of fat increased with the advance of lactation. Thereafter milk was drawn from each sow during the third and seventh weeks of lactation.

Statistical analyses were carried out in accordance with methods outlined by Snedecor (1940). The variance ratio tables of Fisher and Yates (1938) were used in determining levels of significance lower than 1 percent.

Results and Discussion

The individual fat tests of the milk and the average sample volumes collected from the sows are presented in table 3. Only lactations which are represented by two samples, one in the early and one in the advanced stage of lactation, are included in the table. Most of the "early" samples were collected during the third week, and most of the "advanced" ones were obtained during the seventh week.

It can be seen that the fat in the milk increased with the increase in garbage (or fat) consumption and with the advance of lactation. The dif-

ferences in fat tests due to the rations fed were very highly significant (probability less than 0.1 percent). The differences due to stage of lactation were highly significant (probability less than 1.0 percent). Before being analyzed statistically the data were transformed to logarithms because the variances within the individual treatments were roughly proportional to the means.

The increase in fat content of the milk caused by increase in fat intake was much greater than has been reported by various workers making similar

TABLE 3. FAT TESTS AND SAMPLE VOLUMES OF MILK COLLECTED AT TWO DIFFERENT STAGES OF LACTATION FROM SOWS RECEIVING DIFFERENT AMOUNTS OF GARBAGE

Items compared	Ration and stage of lactation					
	Dry concentrate only		¾ garbage ¼ dry concentrate		Garbage only	
	Early	Advanced	Early	Advanced	Early	Advanced
Lactations (No.)	8		7		11	
Fat (percent)						
Range	4.1–8.4	3.9–9.6	4.5–9.8	6.7–11.1	3.5–13.8	7.2–17.6
Average	5.9	6.3	7.0	8.5	7.7	11.5
Volume of sample (cc).						
Range	3.7–10.0	3.1–10.1	5.0–11.2	2.8–7.2	2.3–11.2[1]	2.1–9.1
Average	6.9	6.1	6.8	4.6	6.2[1]	4.8

[1] Does not include one sample of 20.6 cc.

studies with cows and cited by Espe (1941) and Morrison (1936). Levels of fat as high as those in the rations fed the sows were not given to the cows, however. Poor palatability and digestive disturbances would undoubtedly result. Nevertheless, the large fat increases in the milk of the sows suggest that the physiology of milk secretion of this species may differ considerably from that of the bovine. Espe, on the basis of studies made by various workers with goats, suggests that such a difference may exist between goats and cows.

The increase in milk fat with the advance of lactation as observed in these studies with sows is comparable with that of cows.

The average sample volumes presented in table 3 show some differences due to rations. These differences were not significant. There was a decrease

in volume with advance of lactation. The over-all difference due to stage of lactation was highly significant. Such a decrease in sample size could be expected because of the decrease in milk flow with the advance of lactation beyond the third week (Bonsma and Oosthuizen, 1935; Smith, 1937). The volumes of milk obtained at the Hawaii station by hand milking were much smaller than reported as being produced by sows when all the pigs are sucking normally.

The errors resulting from the method of fat analysis and from the method followed in securing the milk from the sows is considerable. It is probable that all the milk in the glands was not obtained. With cows, it is well established that completeness of milking influences the fat test. The differences in the data in table 3 can, however, hardly be attributed to these errors.

The fat content of garbage often varies considerably from day to day. This fact probably accounts for the greater variation in fat tests when the sows were receiving garbage. The literature cited by Espe (1941) and Morrison (1936) shows that any marked increase in fat test caused by increasing fat in the rations of dairy cows is temporary even if the fat intake remains high. To determine whether a high fat intake at a constant level by lactating sows would result in a permanent increase of fat in the milk would require further investigation.

In regard to the effect of the high fat content of the milk upon the suckling pigs, no significant differences were observed in weaning weight or incidence of diarrhea.

Summary

Fifty-two milk samples were collected from eighteen sows during early and advanced stages of lactation. Three different rations were fed during the experiment: (1) dry concentrate only, (2) one-third dry concentrate and two-thirds garbage, and (3) garbage only. On an air-dry, equal-moisture basis the dry concentrate mixture contained 2.8 percent fat and the garbage, 27.1 percent fat.

The fat content of the milk increased with the increase in garbage (or fat) intake and with the advance of lactation. The average fat content of the milk was 6.1 percent when the sows received dry concentrate only and 9.6 percent when they received garbage alone.

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HERITABILITY OF WEANLING TRAITS IN RANGE COLUMBIA, CORRIEDALE AND TARGHEE LAMBS

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BREEDING investigations are being conducted at the U. S. Sheep Experiment Station at Dubois, Idaho, with the aim of improving meat and wool production in Columbia, Corriedale and Targhee sheep, all of which are descended from crosses of long-wool and fine-wool breeds. Stringent selection is practiced on the lambs soon after weaning; hence it is important that genetic merit be evaluated as accurately as possible at this time in order that lambs with superior merit be retained as prospective breeding animals. A knowledge of the heritability of weanling traits is useful in setting up accurate criteria for the selection of lambs. In addition, special studies concerning the efficiency of different breeding systems (Wright, 1939), the relative emphasis due each of several traits when selection is practiced (Hazel, 1943), and the closeness with which a group of young animals can be culled safely on incomplete performance records (Dickerson and Hazel, 1944) must await the accumulation of reasonably accurate information on heritability.

Estimates of heritability of several weanling traits in Columbia, Corriedale and Targhee lambs are reported herein. The traits studied were staple length, weaning weight, body type, condition (degree of fatness), face covering, and neck folds.

Data and Methods

The data used in this study were taken as a routine part of the breeding program of the U. S. Sheep Experiment Station on lambs born from 1941 to 1944, inclusive. No culling was practiced prior to weaning and, except for death losses, the data were free from the effects of selection. No records were eliminated except those which were incomplete in some respect. Records were available on a total of 1711 lambs by 99 sires. The dams of 798 of the lambs had records also, the remainder of the dams being born prior to 1940 when weanling records were first taken. The distribution of the data by breeds is shown in table 1.

In order to minimize environmental differences, records were adjusted where the effects of sex, age of dam, type of birth, age at weaning and percent inbreeding appeared sufficiently large (Hazel and Terrill, 1946b). Half-sib correlations and regressions of offspring on dam were calculated

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for each trait in the three groups, yearly differences being removed by analysis of variance. Since the relationship between half-sibs is 0.25 and that between dams and offspring is 0.50 in non-inbred populations, the half-sib correlation was multiplied by 4 and the offspring-dam regression by 2 to obtain estimates of heritability. Lines of about 30 ewes each, closed to

TABLE 1. DISTRIBUTION OF RECORDS BY BREEDS

Breed	Number of lambs	Number of sires	Number of pairs of offspring and dams
Columbia	820	43	404
Corriedale	316	19	140
Targhee	575	37	254
Total	1711	99	798

outside breeding, were started in each of the three groups in 1941, but the slight inbreeding from this source appeared to have been offset by the relationship between lines due to common inheritance from foundation animals. Standard errors for the half-sib correlations and offspring-dam regressions were calculated as outlined by Fisher (1936), these being multiplied by 4 and 2, respectively, to obtain standard errors for the individual estimates of heritability. Estimates for the three breeds were averaged by weighting each estimate according to the reciprocal of its squared standard error.

Results

The estimates of heritability and the average for the three breeds are given in table 2 for each of the six traits. The three negative estimates obtained by the offspring-dam regression method are obviously sampling errors, but they were used in calculating the averages for those traits because sampling errors in the positive direction cannot be detected with certainty unless they are greater than unity. It is evident that consistently high or low estimates were not obtained by either method of calculation or in any particular breed.

Weaning Weight

The half-sib and offspring-dam estimates of heritability for weaning weight agree very closely for each breed (table 2). Insofar as they accurately represent differences between breeds, the estimates indicate that heritability of weaning weight is highest in Corriedales and lowest in Targhees. The extreme estimates are based on the fewest data (table 1), while the intermediate estimates are for Columbias for which the most data were avail-

able. No valid reason for real breed differences is known but, conversely, there is no certainty that heritability of weaning weight should be the same in the three groups. While it is true that more attention has been given to fleece characters and presumably less to size and weight in the development of Corriedales, both the Columbia and Targhee are young breeds and it is unlikely that selection pressure could have caused much reduction in genetic

TABLE 2. ESTIMATES OF HERITABILITY FOR SIX TRAITS IN COLUMBIA, CORRIEDALE AND TARGHEE LAMBS

Trait	Columbia		Corriedale		Targhee		All breeds	
	Half-sib	Offspring-dam	Half-sib	Offspring-dam	Half-sib	Offspring-dam	Average	Standard error
Weaning weight	0.16	0.21	0.32	0.45	0.08	−0.01	0.17	0.05
Staple length	.38	.46	.05	.40	.60	.49	.43	.06
Body type	.04	.17	.28	.11	.01	−.07	.07	.04
Condition	.13	.11	.34	.41	.31	.16	.21	.05
Face covering	.44	.48	.42	.42	.38	.56	.46	.06
Neck folds	.05	.06	.01	−.06	.17	.15	.08	.04

variability of weaning weight. Since the differences are hardly large enough within themselves to be certain of statistical significance, it is perhaps wise to regard them with reserve.

The weighted average of the six estimates is 0.17 ± 0.05. Hazel and Terrill (1945b) reported an estimate of 0.40 ± 0.04 for the heritability of weaning weight in Rambouillets, and also showed (1945a, 1946b) that several environmental factors had relatively greater influence on weaning weight than on the other weanling traits. The present records were adjusted for known environmental differences, but unknown factors for which adjustment could not be made undoubtedly played an important role in the development of body weight up to weaning time, and these are probably largely responsible for the relatively low heritability of weaning weight.

The estimates of heritability of staple length are reasonably consistent, ranging from 0.38 to 0.60, except for the noticeably low estimate of 0.05 for the half-sib method in Corriedales. The data used in calculating this latter estimate were examined closely, but they appeared as valid as the remaining data except for the lack of sire differences which is responsible for the low estimate. The difference between the two estimates in Corriedales is hardly large enough to be statistically significant. It is evident from the other estimates that length of staple is one of the most highly hereditary of the weanling traits.

The average of the six estimates is 0.43 ± 0.06. Hazel and Terrill (1945b) reported a similar estimate of 0.40 ± 0.05 for Rambouillets.

Body Type

The estimates of heritability of body type vary from 0.28 to −0.07, the latter being an obvious sampling error. The estimates are smaller in each breed than the corresponding estimates of heritability of weaning weight. The breed differences are less marked than those for weaning weight and might perhaps have passed unnoticed except that they are in the same direction. Since a high correlation is known to exist between the two traits, it seems probable that the same factors are responsible for the correspondence between the heritability estimates for the different breeds.

The average estimate of the heritability of body type is 0.07 ± 0.04. Heritability of body type was estimated to be 0.13 and 0.12 in Rambouillet lambs and yearling ewes (Hazel and Terrill, 1946a; Terrill and Hazel, 1943), while McMahon (1943) reported an estimate of 0.15 for "breed type" in Romneys. All of the results to date are similar in that heritability of type is ranked relatively low.

Condition

The estimates of heritability of condition do not vary more widely than might be expected from sampling fluctuations, although the two for Columbias are considerably lower than the others. The average of the six estimates is 0.21 ± 0.05. McMahon (1943) estimated "fleshing" in Romneys to be 0.13 heritable, while Hazel and Terrill (1946a) obtained an estimate of 0.04 ± 0.03 for the heritability of condition in Rambouillet lambs. The Rambouillet lambs averaged lower in condition and were less variable than the lambs in the present study. It may be that condition is more difficult to evaluate in Rambouillets than in other breeds because of their characteristically denser fleeces.

Face Covering

The estimates of heritability of face covering in the three breeds are very uniform, varying from 0.38 to 0.56. The average of 0.46 ± 0.06 is slightly smaller than the average of 0.56 ± 0.05 found by Terrill and Hazel (1946) for Rambouillet lambs. Some breed differences in heritability may be expected because it seems certain that the number and frequency of genes affecting face covering vary in the different breeds. Rambouillets have the most heavily covered faces, and the highest estimate of heritability was found there. Targhees are intermediate in face covering and have the second highest estimate of heritability. However, the differences in the estimates for the different breeds are small, and it is certain that face covering is one of the most highly hereditary weanling traits. A point of interest here is that face covering in all four breeds is influenced less markedly by

measurable environmental factors than are any of the other traits (Hazel and Terrill, 1945a, 1946b).

Neck Folds

Columbia and Corriedale lambs are practically free from neck folds, with slightly greater prevalence in Columbias and the estimates of heritability are very low in these breeds. Neck folds are a little more common in Targhee lambs and the two estimates of heritability are somewhat higher. Neck folds are more prevalent in the Rambouillet flock where an estimate of 0.38 ± 0.05 (Terrill and Hazel, 1946) was obtained. In a Rambouillet flock in Texas where folds were even more prevalent, Jones *et al.* (1946) estimated heritability to be 0.51. These examples form a graded series in which an increase in the incidence and size of neck folds is accompanied by an increase in variability and in heritability. These changes presumably result from increasing frequency of the genes which cause folds. Heritability would be expected to increase along with an increase in genetic variability, provided the variation due to environment and errors of measurement remained relatively constant. Theoretically it would be possible to increase the incidence of neck folds by selection until genetic variability decreased due to approaching gene fixation (Wright, 1931), at which time a relationship opposite to that noted above would exist between average incidence of neck folds and heritability.

Discussion and Application of Results

Heritability in itself gives no indication as to the amount of change which may eventually be effected in a given direction, but the rate of change can be forecast when heritability and selection intensity are known. It is logical that greatest emphasis be given those traits which can be changed most rapidly, since emphasis on weakly hereditary characters is largely ineffective anyway. Characters vary in economic importance as well as in heritability, and maximum over-all progress is attained when the emphasis given each is proportional to the product of its heritability and its relative economic value (Hazel, 1943). Correlations between traits also influence the optimum emphasis for each trait.

The average estimates of heritability of weanling traits found in the present study are: face covering, 0.46; staple length, 0.43; condition, 0.21; weaning weight, 0.17; neck folds, 0.08; and body type, 0.07. The standard errors of the average estimates range from 0.04 to 0.06. The estimates for the individual breeds were not sufficiently different for any of the traits to indicate with certainty that the true heritability actually differed in the different breeds, but those for weaning weight and body type varied con-

siderably. Also, it seems reasonable that heritability for neck folds may be higher in Targhees than in Columbias or Corriedales. With the limited reproductive rate in range sheep and with the present estimates of heritability, rapid progress in changing even one trait at a time is not to be expected. The difficulties are considerably more complex when improvement in several traits is attempted simultaneously, although in a wisely conducted program the over-all progress may be increased considerably thereby (Hazel and Lush, 1942).

In view of the information now available, primary emphasis in culling lambs should be given the more highly hereditary traits, emphasis on body type and neck folds being limited to culling those lambs which have obvious body defects and definite folds. It would seem wise to leave some room for subsequent culling on yearlings after additional information on fleece weights have been obtained. Selection for body type and neck folds could be emphasized on the parents from progeny information which regularly becomes available each year. It is not clear that systematic use of progeny-tested sires (to the extent of requiring that every ram be tested prior to extensive use) would increase the over-all rate of progress. When the progeny of a ram are good it is obvious that he should be used extensively; when they are mediocre a promising young ram might more wisely be chosen to replace him.

Different problems are likely to be encountered with the different breeds. For example, most Columbias are not subject to wool-blindness, and there appears to be little object in breeding more wool off the face than is necessary for unobstructed vision. Emphasis on fleece and mutton characters may need to be varied depending on the particular breed, market conditions and local environment. For example, Columbia lambs are heavier and score better in type and condition, while Corriedale lambs have longer staple (Hazel and Terrill, 1946b) and it is unlikely that all breeders would prefer the same emphasis on each of the traits in the two breeds. More specific information along this line can be obtained after the changes in dollars-and-cents income and outgo of the range enterprise which are associated with a given amount of change in each of the weanling traits have been examined.

Summary

Records were studied on Columbia, Corriedale and Targhee lambs at the U. S. Sheep Experiment Station, Dubois, Idaho, to obtain estimates of heritability of several weanling traits. These estimates of heritability represent the proportion of the gain which is transmitted to the offspring through selected parents. Estimates were made from half-sib correlations based on

1711 lambs by 99 sires and from regressions of offspring on dam based on 798 pairs.

Estimates were not consistently higher or lower with either method of estimation or for a particular breed, but some traits were definitely more highly hereditary than others. The average estimates of heritability and their standard errors were: weaning weight, 0.17 ± 0.05; length of staple, 0.43 ± 0.06; body type, 0.07 ± 0.04; condition 0.21 ± 0.05; face covering, 0.46 ± 0.06; and neck folds, 0.08 ± 0.04.

An increase in the incidence and size of neck folds in different breeds was found to be accompanied by an increase in variability and heritability which was consistent with genetic theory.

The results indicate that face covering and staple length can be changed most rapidly by selection, followed by condition and weaning weight. Further progress toward complete elimination of neck folds will be slow but these breeds are already practically free from folds. Even the most intense selection that can be practiced and the most efficient breeding systems which can be used with sheep will not be sufficient to induce marked improvement in body type because of its low heritability.

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A COMPARISON OF THE WIRA TYPE DENSITY CALIPER WITH THE ELECTRIC DENSITY CLIPPER

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FLEECE density is an important factor to consider in the selection of sheep for wool production since it is directly related to the amount of wool obtained. Therefore, since a large number of animals are under consideration, the method employed for the measurement of density should be rapid, as well as accurate.

The caliper method for sampling wool has been found too slow for use when the wool from many animals is to be tested for density.

Recently an electric clipper has been designed for taking density samples one square centimeter in size from the skin of sheep. This method of obtaining samples has been found to be about three times as fast as methods involving use of the density caliper. The purpose of the present paper is to compare the relative efficiency of these two methods of sampling.

Materials and Methods

Fleeces of 20 Rambouillet wethers were sampled at the Agricultural Research Center, Beltsville, Maryland. Four samples were taken with the density clipper and four with the density caliper from the left shoulder and left side regions from each of the 20 sheep.

The electrically driven density clipper removes the wool in parallel swaths around the one centimeter square area to be sampled. Its application and construction are described by Hardy (1942). The caliper used is of the Wira design (Wildman, 1936). The sample in this case is taken by the double insertion technique, i.e., the caliper is inserted, fibers parted, and the caliper removed. The instrument is then re-inserted at right angles to the parted swath, the fibers are again parted leaving a tuft of wool clamped between the jaws of the caliper. The wool is then removed by clipping it close to the skin.

Fiber density, the number of wool fibers per square centimeter of skin area, was estimated by the cross-sectional area method which consists of measuring the area of a cross-section of a wool-fiber bundle one quarter inch from the base end of each bundle. The bundle of fibers is held in a slot 0.045 inch wide and 0.625 inch deep and the depth of the fibers in the slot is measured in thousandths of an inch under a dead-weight load of five kilograms. All measurements were taken under controlled conditions of tem-

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perature, humidity, and pressures; and all samples were first cleaned in carbon tetrachloride. This method was reported by Hardy and Wolf (1942).

Experimental Results and Discussion

The results obtained by the clipper and caliper were quite similar in the manner in which they ranked the 20 experimental wethers, as indicated in table 1. The correlation coefficient between the fiber densities as determined by the two instruments was 0.78, which is highly significant. In-

TABLE 1. FIBER DENSITY AS DETERMINED BY THE TWO METHODS

Sheep No.	Electric density clipper		Wire type caliper	
	No. Per Sq. Cm.	Rank[1]	No. Per Sq. Cm.	Rank[1]
1	6258	14	4186	12
2	4515	20	3302	20
3	6296	12	4260	11
4	5543	17	4049	13
5	4592	19	3950	16
6	5581	16	3769	18
7	6468	9	5315	2
8	5310	18	4013	14
9	7539	2	5272	3
10	6709	7	4495	8
11	6985	5	4621	6
12	6405	11	4447	9
13	7304	4	4685	5
14	5894	15	4403	10
15	6554	8	4002	15
16	6266	13	3921	17
17	6771	6	4805	4
18	6324	10	3767	19
19	8616	1	5755	1
20	7424	3	4552	7
Mean	6368	—	4379	—

[1] Ranked in descending order as to fiber density.

spection of individual density values indicate that both the caliper and the density method showed the fleece from sheep number 2 to be the least dense and that from sheep number 19 to be the most dense. These findings indicate that results of selection with the two would be fairly comparable. The average fiber density of the 20 fleeces was 6368 fibers when sampled by the clipper and 4379 by the caliper, as shown in table 1. Significant differences between sheep and between regions were revealed by both methods. However, the difference between samples within regions was not significant in case of the caliper. The sampling errors were 1258 fibers using the clipper

and 762 fibers using the caliper. Based on these errors, the relationship between the number of samples per region and the number of fibers required for a significant difference is shown in table 2. For example, to make a difference of 700 fibers significant, six samples would be required if the caliper was used and 14 if the clipper was employed.

TABLE 2. REQUIRED NUMBER OF OBSERVATIONS PER REGION TO SHOW FIBER DENSITIES THAT ARE SIGNIFICANTLY DIFFERENT

Observations per region	N-Total observation for 2 regions	Degrees of freedom	$\sqrt{\frac{2}{N}}$	t value, 5% level	Necessary difference[1]	
					Clipper $\sigma = 1258f$	Caliper $\sigma = 762f$
1	2	1	1.000	12.706	15,984	9,682
2	4	3	.816	3.182	3,266	1,978
3	6	5	.632	2.571	2,044	1,240
4	8	7	.534	2.365	1,592	964
6	12	11	.426	2.201	1,179	714
8	16	15	.365	2.131	981	593
10	20	19	.324	2.093	856	517
12	24	23	.295	2.069	770	465
14	28	27	.272	2.052	702	425
16	32	31	.254	2.042	652	395

[1] The differences were calculated with the formula $D = ts\sqrt{\frac{2}{N}}$ where:

D = Number of fibers

N = 2 times the number of observations per region

s = The best estimate of error, 1258 fibers for clipper and 762 fibers for the caliper.

t = Values from Snedecor, page 13—table 3.8

Samples were taken from the side region of the animals with greater ease than from the shoulder area. Closer agreement between samples within the side region may result because of the inherent homogeneity of the density within the side regions compared to the distinct gradient within the shoulder region.

Although both the clipper and the caliper are capable of yielding a sample which will differentiate fleeces on the basis of fiber density, there appears to be a distinct difference between the instruments. In every case the electric clipper took a larger sample than the caliper. This difference is difficult to explain. However, it is generally believed that the position of the animal and possible movements of the skin during sampling have a direct bearing on the results obtained.

The caliper shows less error in sampling density than the clipper as shown by the fact that more than twice as many samples are required by the clipper to get the same accuracy as with the caliper. It is possible that the error with the clipper method can be reduced by developing a clipper

with which larger samples can be obtained, since Wolf, Dawson and Pohle (1943) have shown that increasing the size of skin area sampled increases the accuracy of determining fiber density, at least up to an area of about three square centimeters. Further work is needed on this point.

Conclusions

The electric clipper and the Wira caliper for determining density of fleeces have been compared, and it is evident that both instruments may have a useful place in sheep breeding research. With the density clipper satisfactory samples may be obtained more rapidly and with much less skill on the part of the operator than by the density caliper. The Wira caliper is more accurate and can be used in sampling small numbers of sheep, although either instrument may be used with satisfactory results. However, with large flocks of sheep, the speed required would necessitate use of the density clipper, even though some accuracy must be sacrificed. Further work is needed to test the possibility of increasing accuracy with the electric clipper by sampling a larger area.

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EFFECTS OF SOME ENVIRONMENTAL FACTORS ON FLEECE AND BODY CHARACTERISTICS OF RANGE RAMBOUILLET YEARLING EWES

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MANY nongenetic, or environmental, factors are known to influence the performance and appearance of young sheep, thereby obstructing efforts to select those animals having the greatest breeding value and reducing the progress which might be accomplished by selection. Many of these factors are difficult to control, particularly under range conditions, but allowances can be made where the effects of various factors are known, in order to place animals on a more comparable basis.

Phillips and Dawson (1940) found that several birth factors affected the growth, survival and selection of Hampshire, Shropshire and Southdown lambs, differences being more pronounced at 3 months than at 6 months and tending to disappear by the time the lambs had reached 12 months of age. Hazel and Terrill (1945) studied several factors as they influenced weaning weight, staple length, body type, condition, face covering and neck folds in range Rambouillet lambs. The present study was undertaken to ascertain the importance of factors which affect the fleece and mutton characteristics of yearling Rambouillet ewes under Intermountain range conditions. The factors studied were age of dam, type of birth, year of birth, breeding group, age and percent inbreeding.

Data and Methods

The data used in this study were taken on 932 yearling Rambouillet ewes, survivors of an original group of 1449 ewe lambs on which weanling traits were studied previously (Hazel and Terrill, 1945). A few ewes died or were lost between weaning and yearling age but most of the difference in numbers was due to the culling practiced soon after weaning.

Staple length was measured and scores for face covering were taken just prior to shearing by a committee of three men working independently. Fleeces were weighed on the shearing floor and body weights were taken immediately thereafter. Clean fleece weights were estimated from the clean yields of small side samples (about 35 grams) and grease fleece weights on the yearlings born in 1941. Scores for body type, condition and neck folds were taken by a committee of three men a few days after shearing. The scoring system was the same for the four traits evaluated by scoring: ewes consid-

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ered as having highest merit were given a score of 1 and those having lowest merit a score of 5. Fifteen scoring units were obtained by assigning plus or minus values where merit appeared to be slightly above or below the whole unit.

The analysis was carried out as suggested by Yates (1934) for multiple classification tables with unequal numbers, except that the method was extended according to least squares procedure to include age at shearing and percent inbreeding as independent variables (Hazel, 1946). The age at shearing, which averaged 406 days, was used in the analysis as the age at which each of the traits was measured. The percent inbreeding ranged from 0 to 39.1 percent with an average of 4.54 percent. In the analysis, classifications were made for age of dam (mature and 2-year-old dams), type of birth (singles, twins and twins raised singly), year of birth (1941 and1942) and breeding group (A and B). All dams three years of age and over were classified as mature. The yearlings in group A were somewhat older and more inbred than those in group B but the system of management after weaning was the same for the two groups. The sires of group A were the first choice sires having been progeny tested previously or considered good enough to use without having been tested, while the sires of group B were the next best group undergoing test prior to subsequent use in group A.

Results

The means, standard deviations within classes, differences due to age of dam, type of birth, year and group, and the regressions of each trait on age at shearing and percent inbreeding are summarized in table 1. Many of the differences, although statistically significant, were too small to be important, in the sense that they accounted for relatively small percentages of the total variation. Those large enough to account for 2 percent or more are designated in table 1. Table 2 shows the analysis of variance and the percentages of the total variance in each trait which could be attributed to the combined effects of all the factors studied.

Length of Staple

Yearling ewes from mature dams had 0.12 cm. longer staple than those from 2-year-old dams. Staples of singles were 0.30 and 0.35 cm. longer than those of twins and twins raised singly, respectively. The effect of type of birth was greater on yearlings than on the same animals as lambs, while that of age of dam was less (Hazel and Terrill, 1945). The yearlings in group A and those born in 1942 had longer staple than the contrasting groups, whereas differences between groups and years were small at weaning.

The regression of staple length on age at shearing was 0.011 cm., com-

TABLE 1. MEANS, STANDARD DEVIATIONS, DIFFERENCES IN MAIN FACTORS AND REGRESSION COEFFICIENTS FOR YEARLING TRAITS

Statistic	Staple length	Grease fleece weight	Clean fleece weight[1]	Body weight	Body type	Condition	Face covering	Neck folds
	centimeters	*pounds*	*pounds*	*pounds*	*score*	*score*	*score*	*score*
Mean	6.75	8.30	3.98	81.9	2.24	2.19	4.74	1.84
Standard deviation	0.70	1.09	0.57	7.9	0.36	0.28	0.47	0.42
Mature minus 2-year-old dam	0.12	0.58*	0.17	2.6	0.05	0.01	0.01	0.12
Single minus twin	.30*	.81*	.23*	6.0*	− .14*	− .10	.07	.08
Single minus twin raised singly	.35*	.37*	.17*	0.5	− .05	− .02	.02	.02
1942 minus 1941	.47*	.12	—	6.9*	− .09	− .09*	− .01	− .28*
Breeding group A minus Breeding group B	.26*	.13	.09	5.7*	− .19	− .06	.06	− .04
Regression on age at shearing	0.011	0.026*	0.011	0.031	0.001	0.007*	−0.005	0.002
Regression on percent inbreeding	−0.009	−0.019	−0.011	−0.278*	−0.011*	0.007*	0.003	−0.003

[1] The clean fleece weights were practically free of moisture, since the samples were dried in a conditioning oven at 212° F. for 6 hours, whereas clean wool on a commercial basis contains 12 percent moisture.

* Signifies that the statistic is large enough to account for 2 percent or more of the total variation in that trait.

parable with 0.012 cm. noted for lambs. These regressions are too small to account for the average length of staple attained at weanling and yearling ages (2.66 and 6.75 cm., respectively). A similar discrepancy was observed in Columbia, Corriedale and Targhee lambs (Hazel and Terrill, 1946).

The regression of staple length on percent inbreeding evidently is asso-

TABLE 2. SUMMARY OF ANALYSIS OF VARIANCE FOR EACH OF EIGHT YEARLING TRAITS

Source of variation	Degrees of freedom	Staple length	Grease fleece weight	Clean fleece weight[1]	Body weight	Body type	Condition	Face covering	Neck folds
Total	931	0.61	1.69	0.37	86	0.14	0.09	0.23	0.19
Age of dam	1	2.31*	49.53**	1.75*	1,117**	0.03	0.00	0.01	1.39**
Type of birth	2	9.54**	52.68**	2.30**	2,822**	1.52**	0.64**	0.28	0.66*
Year of birth	1	47.08**	1.14	—	10,298**	1.39**	2.64**	0.03	18.80**
Breeding group	1	26.37**	1.72	5.65**	4,444**	1.61**	0.50*	2.44**	0.13
Age at shearing	1	5.23**	59.03**	1.65*	27	0.05	2.57**	1.24*	0.26
Percent inbreeding	1	3.88**	15.18**	2.99**	3,639**	6.02**	2.25**	0.52	0.30
Within main classes	924	0.49	1.21	0.32	62	0.13	0.08	0.22	0.18
Percent of total variation accounted for		21	29	14	28	9	11	3	11

[1] The analysis for clean fleece weights was based on only 497 yearlings born in 1941.

* Signifies probability of chance occurrence $< .05$.

** Signifies probability of chance occurrence $< .01$.

ciated with age, since it was −0.009 cm. for yearlings and only −0.003 cm. for lambs at weaning. It seems from this that inbreeding may cause a slight depression in the rate of increase in staple length, the extent of the depression depending upon the amount of inbreeding, so that regressions differ according to the length of time the fibers have been growing. It should be noted, however, that the detrimental effect of inbreeding upon staple length is actually not severe at the levels of inbreeding encountered in this study.

Differences due to type of birth, group and year were each important enough to account for more than 2 percent of the total variation in staple length. All of the factors studied accounted for 21 percent of the variation.

Grease Fleece Weight

Fleeces from yearling ewes from mature dams weighed on the average 0.58 pound more than those from yearlings from 2-year-old dams. Single yearling ewes produced 0.81 pound more grease wool than twins and 0.37 pound more than twins raised singly. Differences due to age of dam and type of birth were highly significant (table 2), accounting for 3.1 and 6.7 percent of the total variation, respectively. The average fleece weights for the 2 groups and the 2 years were very similar.

Thr regression of grease fleece weight on age at shearing was 0.026 pound. The average fleece weight was 8.30 pounds at 406 days, indicating an average increase per day from birth to shearing of 0.020 pound. The regression on percent inbreeding, which was −0.019 pound, was too small to be considered an important source of variation.

Differences attributed to age of dam, type of birth and age at shearing were large enough to be adjusted in selecting for heavier grease fleece weight. All of the factors accounted for 29 percent of the total variation.

Clean Fleece Weight

Yearling ewes which had mature dams produced 0.17 pound more clean, scoured wool than those which had 2-year-old dams, while singles produced 0.23 and 0.17 pound more than twins and twins raised singly, respectively. These differences, being on a clean, dry wool basis, are reasonably consistent with the corresponding differences in grease fleece weight.

The regression of clean fleece weight on age at shearing was 0.011 pound, while the average increase per day from birth to shearing was 0.010 pound as judged by the average clean fleece weight of 3.98 pounds. The regression of clean fleece weight on percent inbreeding was −0.011 pound, which was statistically significant but not large enough to be an important source of variation.

Body Weight

Yearling ewes from mature dams were 2.6 pounds heavier than those from 2-year-old dams, while single lambs were 6.0 and 0.5 pounds heavier than twins and twins raised singly, respectively. The differences are in the same direction as at weaning but are considerably smaller (Hazel and Terrill, 1945). Phillips and Dawson (1940) observed that lambs tended to overcome an original handicap in growth rate by the time they were 12 months of age. The yearlings in 1942 were 6.9 pounds heavier than in 1941, whereas no difference between years was evident on the lambs. The average body weight of the 932 yearlings was 81.9 pounds at 406 days, while the average weaning weight of the original 1449 ewe lambs was 60.7 pounds at 124 days (Hazel and Terrill, 1945). The difference represents an average gain of only 21.2 pounds in 282 days and can be attributed only to a very marked decrease in growth rate following weaning. The regression of yearling body weight on age was 0.031 pound as compared with 0.413 pound at weaning. Phillips, Stoehr, and Brier (1940) noted the reduction in growth rate following weaning in range Corriedale and Rambouillet ewe lambs. The regression of body weight on percent inbreeding was 0.278 at yearling age as compared with that of 0.375 at weaning.

All of the factors except years and groups were less important sources of variation in yearlings than in lambs, indicating that the effect of environmental factors on growth rate was reduced after weaning. The effect of inbreeding, which appeared severe on the lambs, was not nearly so important on yearlings.

Body Type

Singles received significantly better scores at yearling age than twins or twins raised singly, but the corresponding differences were much larger at weaning (Hazel and Terrill, 1945). The difference due to age of dam and the regression of body type on age were not large enough to be significant. The better scores for the yearlings in 1942 than in 1941 was probably due to their greater size and weight. The detrimental effect of inbreeding on type score was apparently as pronounced on yearlings as on lambs. Only type of birth and percent inbreeding were important enough to require adjustments in the body type scores of yearlings. All of the factors accounted for 9 percent of the total variation in body type scores at yearling age as compared with 15 percent at weaning.

Condition

Singles were given slightly better condition scores than twins raised singly, which in turn were given better scores than twins raised as twins.

These differences were significant but not large enough to be important. The difference due to age of dam was very small. The yearlings in group A and those born in 1942 exceeded the contrasting groups in condition, as might be expected from the corresponding differences in body weight and type score. The regression of condition score on yearling age was positive and highly significant, indicating that the older yearlings were poorer in condition than the younger ones. The detrimental effect of inbreeding, as measured by the regression of 0.007, was not quite as severe as that noted at weaning. Only the difference between years and the effects of age and inbreeding were large enough to account for more than 2 percent of the total variation. Eleven percent of the total variation in condition score could be attributed to the combined effects of all the factors.

Face Covering

The amount of wool on the face was influenced only slightly by the environmental factors which accounted for less than 3 percent of the total variation in face covering. The difference between groups and the regression of face covering on age at shearing were statistically significant but were not large enough to be important.

Neck Folds

Single yearlings and those from mature dams had more neck folds than twins and those from 2-year-old dams. These differences are smaller but are in the same direction as those for lambs (Hazel and Terrill, 1945). The yearlings born in 1942 were considerably smoother than those born in 1941 and part of this difference is probably genic, being due to the selection practiced for smoothness. None of the differences except that between years was large enough to be an important source of variation in neck folds.

Discussion

Some of the traits were influenced much more strongly by the environmental factors studied than were others. It is particularly noticeable that most of the factors had relatively greater effects upon the characters which are measured by an objective quantitative standard (grease fleece weight, body weight, staple length and clean fleece weight) than upon those which are evaluated by subjective scores (condition, neck folds, body type and face covering).

The effects of age of dam, type of birth and differences in age were generally in the same direction on yearlings as on weanling lambs (Hazel and Terrill, 1945), but they were relatively smaller on yearlings. Phillips and Dawson (1940) observed that lambs handicapped by birth factors with adverse effects upon growth rate tended to overcome those handicaps by the

time they reached yearling age and this appeared to be true with the present animals also, although the differences were by no means entirely eliminated at yearling age.

The yearlings in group A excelled those in group B in every characteristic except face covering, most of the differences being statistically significant. The sires of group A were the first choice sires, having been progeny-tested previously or considered good enough to use without having been tested, while the sires of group B were the next best group undergoing test prior to subsequent use in group A. Hence some of the group differences may have been genetic rather than environmental.

Inbreeding had relatively greater detrimental effects on the mutton characters (body weight, body type and condition) than on the fleece characters (staple length, grease fleece weight and clean fleece weight). The effects of inbreeding on face covering and neck folds were negligible.

Summary

The effects of age of dam, type of birth, year of birth, breeding group, age at shearing, and percent inbreeding were studied on 932 range Rambouillet yearling ewes, born in 1941 and 1942.

Grease fleece weight, clean fleece weight, yearling body weight and staple length, which were evaluated by a quantitative standard, were more strongly influenced by the environmental factors than were condition, neck folds, body type and face covering, which were evaluated by scoring.

Yearling ewes from mature dams and singles were heavier, had longer staple and produced heavier grease fleeces and more clean wool than those from 2-year-old dams and twins, respectively.

The detrimental effects of inbreeding were more pronounced on the mutton characters (body weight, body type and condition) than on the fleece characters (staple length, grease fleece weight and clean fleece weight).

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ABSTRACTS OF PAPERS TO BE PRESENTED AT THE THIRTY-EIGHTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meetings are scheduled to be held at the Hotel Sherman in Chicago on November 29 and 30, 1946, with a dinner for the honor guest on December 1.

Animal Breeding Section

R. E. Comstock, *Chairman*

THE HERITABILITY OF SOME FACTORS AFFECTING PRODUCTIVITY OF BROOD SOWS.

J. N. Cummings, L. M. Winters, and H. A. Stewart, *University of Minnesota.*

Heritability estimates of five factors affecting productivity of brood sows during the pre-weaning period are reported in this study. Each was determined by doubling the intra-sire regression of the daughter's record on the dam's record using data from the farrowing and pre-weaning records on the first litters of gilts used in the Minnesota swine breeding project from 1938 to 1944, inclusive. Altogether, 532 daughter-dam comparisons were included. The heritabilities as determined in this study were as follows: (1) survival from birth to weaning, 40 percent; (2) size of litter at birth, 22 percent; (3) total litter weight at birth, 36 percent; (4) size of litter at weaning, 32 percent; and (5) total weaning weight of the litter, 7 percent. The heritability of the total weaning weight of the litter with the effects as size of litter and survival eliminated (determined by partial regression), was found to be 59 percent. It is suggested that this heritability might be a close approximation for that of milk production. It is also pointed out that these heritabilities, as well as many others, have restricted limitations and should be applied mainly as descriptions of the populations from which they were derived. It is not intended to imply that their significance has been jeopardized but that they may be used advantageously as guides to further improvement through selection within the particular herds or lines.

A REPORT OF PROGRESS ON THE CROSS-BREEDING OF DAIRY CATTLE.

M. H. Fohrman and O. E. Reed, *U. S. Department of Agriculture.*

Results of experimental breeding work with dairy cattle accumulate slowly, final reports cannot be complete until all of the animals involved have had an opportunity to express their inherited ability to produce milk and butterfat. A summary of the average milk and butterfat records made by 38 two-breed heifers and 9 three-breed heifers is given. These are unselected animals, all handled under the same environmental conditions. The 38 heifers have produced on the average 12,904 lbs. of milk and 588 lbs. of butterfat, average test 4.60 percent at an average age at calving of 2 years 2 months. The nine three-breed animals are combinations of Holstein, Jersey, Red Dane, and Guernsey, 5 sired by Red Dane bulls, 2 by Holsetin, 1 by a Jersey, and 1 by a two-breed bull. These nine unselected heifers produced on the average 14,833 lbs. of milk and 645 lbs. of butterfat, average test 4.36 per cent, average at calving 2 years. The average of the 47 is 13,273 lbs. of milk and 599 lbs. of butterfat. Forty-three of the 47 produced more butterfat than their dams in the same lactation period. All of the records given are actual records made under standardized conditions on 3 milkings daily for 365 days. This paper gives a breakdown in the average production by breed combinations, and a full explanation of plan of the experiment, with some additional information on production of animals with incomplete records in the later generations.

EFFECTIVENESS OF SELECTION FOR EFFICIENCY OF GAIN IN DUROC JERSEY SWINE. G. E. Dickerson and J. C. Grimes, *United States Department of Agriculture and Alabama Experiment Station.*

Beginning with a common foundation stock in 1937, one line was selected for low and another for high feed requirements per unit of gain from 72 days to a live weight of 225 pounds. Pigs were full-fed individually. Eight litters were raised per line each year. The plan was to select the best (or poorest) boar and gilt in each litter and mate the least related pairs. The divergence between the lines during 5 generations was significant and indicated that differences, in feed requirement, largely between littermates, were about 24 percent heritable. Heritability of differences between pigs from different litters was estimated from regression of progeny on the mean of the parents, within line and year of progeny and parents (62 degrees of freedom). In percent, the estimates were 26 for feed requirements, 43 for rate of gain, 47 for length of feeding period, 9 for 72-day weight, and 0 for birth weight. For feed requirement, regression of progeny on sire was much larger (.23) than on: dam (.01), indicating genetic antagonism between the dam's direct and transmitted influences. Corresponding regressions for rate of gain were .24 and .29, respectively. Apparently, milking ability was more closely associated with inherent maintenance requirements or efficiency of assimilating food than with rate of gain or food consumption. Estimates of genetic correlation between rate and economy of gain were $-.7$ or larger. These results suggest that selection for rapid gain would be nearly as effective in improving efficiency as selection based on feed records.

CALF MORTALITY IN RELATION TO INBREEDING. W. M. Regan, S. W. Mead and P. W. Gregory, *University of California.*

An analysis of calf mortality in the University of California dairy cattle breeding experiment is presented. Calves up to 4 months of age that were the result of single conceptions were included. Only those stillbirths and abortions from cows free from Brucellosis and health and reproductive abnormalities were considered. A total of 774 Jersey and 258 Holstein calves were included. Calves were classified according to inbreeding coefficients as follows: Class I, the controls 0.0 to 0.1249; Class II, 0.125 to 0.2448; Class III, 0.245 to 0.3749; and Class IV 0.375 and over. There was no relation between the number of abortions and the degree of inbreeding. The stillbirths, too few to be statistically significant, tend to increase as the coefficient of inbreeding increased. Following birth, however, mortality was correlated with inbreeding of both males and females but for the males it was significantly greater than for the females in Classes III and IV. The Jerseys tended to be less viable than the Holsteins. Some of the increased mortality of the more highly inbred animals could be accounted for, by the action of two lethal genes; one controlling an anomaly of the liver, the other an anomaly of the heart, there was no plausible explanation for most of it. Within sex, inbreeding class, and breed there was considerable variation in the mortality of the progeny of different sires. Some of these differences were statistically significant.

INFLUENCE OF INBREEDING ON GROWTH AND PRODUCTION OF HOLSTEIN-FRIESIAN CATTLE. W. J. Tyler, *West Virginia University,* G. E. Dickerson, *United States Department of Agriculture,* and A. B. Chapman, *University of Wisconsin.*

The objectives of this study were to determine the extent and variability of inbreeding effects in dairy cattle on birth weight, size at six months, 18 months and maturity, and on milk and butterfat production and butterfat-test by comparisons of inbred and outbred progeny of the same sires. The intra-sire regression of the birth weight of 654 calves adjusted for the influence of size of dam on their own percentage of inbreeding was significant ($b = 0.28$ lb.). Similar partial regressions of dimensions (height at withers, circumference of shin bone, heart girth and width at hips) on inbreeding at six months of age (255 calves) and at maturity (111 cows) were not significant. At 18 months of age (152 heifers), however, the partial regression of heart girth on inbreeding was significant and negative ($b = -0.11$ cm); none of the other partial regressions for body dimensions at this age were significant. Intra-sire partial regressions (holding dam's record constant) of 305-day milk and butterfat production on inbreed-

ing for 46 inbred (average inbreeding = 0.14) and 47 outbred cows were significant and amounted to a decrease of 73 lbs. of milk and 2.3 lbs. of butterfat for each one percent increase in inbreeding. The average fat percentages of inbred and outbred daughter groups were not significantly different. The variation in these partial regression coefficients between sires was large enough that the offspring of some sires might be inbred as much as 25 percent without any apparent decrease in either body size or milk and butterfat production.

WHY IS THE ABERDEEN-ANGUS BREED HOMOZYGOUS FOR POLLED? Heman L. Ibsen, *Kansas State College.*

In the Aberdeen-Angus breed you sometimes see a red calf that has been produced by purebred parents, but you never see a horned animal. Both black and polled are due to dominant genes, and therefore there must be some special reason for the breed being homozygous for polled. The explanation offered is based on many known facts, but the evidence is not complete. Usually the quickest and surest aid in reaching homozygosity quickly for a dominant gene is to be able to distinguish the heterozygotes from the homozygous dominants and to use only the homozygotes as breeding animals. Incomplete dominance does not apply in the present case. Instead, it seems plausible that some other gene acted as a marker for the heterozygous polled (*Pp*) males. This gene I have called *Ha* ("African" horns). In males it is epistatic to polled. The polled ancestors of the Aberdeen-Angus were crossed frequently with horned animals. The latter at that time seems to have been to a large extent homozygous for *Ha*. The theory advanced is that *Ha* is closely linked with *p* (absence of polled). Thus every heterozygous polled male would be *P ha*, *p Ha*, and therefore horned, while every clean polled bull would be homozygous for polled (*P ha*, *P ha*). By using only clean-polled bulls each generation it would not take very many generations before all the animals in the breed would be *PP*. It is possible to test the theory at the present time by making appropriate matings.

SEASONAL VARIATIONS IN THE OCCURRENCE OF CONCEPTIONS IN KARAKUL SHEEP. Ralph W. Phillips, R. G. Schott and V. L. Simmons, *United States Department of Agriculture.*

Karakul ewes are reputed to exhibit estrus more frequently in the spring and early summer than most breeds and to be able to produce two lambs crops per year in many cases. Published experimental evidence is limited and conflicting. For about four years, beginning in July, Karakul and high-grade Karakul females, 6 months of age and over, were kept constantly with rams. Incidence of conceptions, in open ewes, by months from January through December, were 9.5, 14.2, 6.6, 0.0, 0.5, 0.0, 10.3, 35.0, 46.5, 20.5, 23.1 and 11.5 percent, respectively. In lactating ewes, only 12 conceptions occurred, and these were during the normal breeding season, 2 in September and 10 in October. These represented 7.5 and 52.6 percent of lactating ewes exposed to mating in those months; in all other months, percentage of conception was zero. In lambs 6 to 12 months of age, no conceptions occurred during February to August, inclusive. From September through January, percentages of conception were 1.6, 33.3, 39.0, 7.4, and 26.1. These results indicate that Karakul ewes have a limited breeding season and that not all ewes in such flocks can be expected to mate freely in any part of the year. Thus the possibilities of obtaining two lamb crops per year in practical breeding operations appear to be limited. They also show that relatively few pregnancies occur in ewes nursing lambs, except when at the peak of the natural mating season.

THE EFFECTIVENESS OF CAROTENE AND FAILURE OF ASCORBIC ACID TO INFLUENCE SEXUAL ACTIVITY AND SEMEN QUALITY OF VITAMIN A DEFICIENT BEEF BULLS. Louis L. Madsen, O. N. Eaton, Louis Heemstra, Russell E. Davis, Charles A. Cabell, and Bradford Knapp, Jr., *United States Department of Agriculture.*

Observations are recorded on the reproductive performance of six first generation Hereford×Shorthorn bulls reared on a carotene deficient basal diet supplemented with restricted levels of alfalfa, which furnished 45 to 140 micrograms of crude carotene per kilogram of body

weight daily. One bull on the 45 microgram level showed symptoms of vitamin A deficiency as a calf and later failed to demonstrate copulatory ability. Successful semen collections and fertility were established in the other five bulls, all of which received 50 micrograms or more of crude carotene per kilogram of live weight. At the end of a preliminary semen collecton period, two of the bulls were subjected to a period of vitamin A depletion and the other three were continued on their respective levels of carotene intake for control observations. The progress of the degree of vitamin A deficiency was followed by chemical determinations of carotene and vitamin A in the blood plasma and ascorbic acid in the blood plasma and semen. Sexual activity and ability decreased rapidly with the development of symptoms of vitamin A deficiency. Semen samples collected as the depletion progressed showed marked increases in percentage of abnormal spermatozoa and cellular debris with progressive decline in motility. Injections of ascorbic acid failed to stimulate sexual activity or modify the quality of the semen produced by the vitamin A deficient bulls. Carotene feeding, on the other hand, restored the bulls to apparently normal activity and semen production. However, histological evidence of previous testicular injury due presumably to vitamin A deficiency was evident after as long as 20 months of carotene feeding.

BIRTH WEIGHT AS A MEASURE OF SELECTION IN BEEF CATTLE. W. M. Dawson, Ralph W. Phillips and W. H. Black, *United States Department of Agriculture.*

Birth weights of calves in the beef Shorthorn herd at Beltsville, Maryland tended to increase at the rate of 0.2 lb. per month of increase in age of dam until dams were six years old, after which there was no effect. Correlations between age of dam and birth weight were 0.45 for male and 0.35 for female calves. When birth weights were adjusted to the basis of six-year-old dams, males averaged 4.2 lbs. heavier than females. Using only male calves, weight of dam was related to birth weight of calf to about the same extent as was age of dam, and a multiple correlation between both age and weight of dam and birth weight was little higher than the simple correlations. Correlation between the length of gestation period and birth weight was 0.32. Using paternal half sib correlation, heritability of original birth weights was 29 percent while for birth weights corrected for age of cow, sex, and dam's index (average weight of all calves from a given dam), heritability was 11 percent. Using only calves which were fed out as steers, largest calves at birth and those with highest prenatal growth rates tended to reach 500 lbs. (weaning weight) and 900 lbs. (slaughter weight) sooner. There was little relationship between birth weight or prenatal growth rate and length of feeding period from weaning to slaughter. Correlations between birth weight or prenatal growth rate and economy of gain during the feeding period were practically zero.

PRACTICAL APPLICATIONS OF HERITABILITY STUDIES OF BEEF CATTLE CHARACTERISTICS IN BREEDING PROBLEMS. Bradford Kanpp, Jr., *United States Department of Agriculture, Miles City, Montana.*

Data on the performance of approximately 600 steers from 70 different Hereford sires have been accumulated at the U. S. Range Livestock Experiment Station and the Montana Agricultural Experiment Station. The results show that growth and efficiency were highly heritable. Live animal scores, grades, and certain carcass characteristics were less heritalile than growth and efficiency but that there was ample opportunity for further selection in these traits. Dressing percentage was proven to be only very slightly heritable. Gain in the feed lot is approximately 85 percent heritable. Heritability of gains in the feed lot increases as the feeding period progresses. Based on the above a program of beef cattle selection and improvement is suggested. Since post-weaning growth rate is 80 to 95 percent heritable, the unbiased comparative feeding of prospective bulls after weaning is to be recommended. All prospective bulls should be fed the same ration, and the natural appetite should be the determining factor on the quantity of feed. Selection for conformation points may be done at two or three different times. The faster gaining bulls of the desired type should be selected for breeding. Examples of selection for gaining ability are given. Carcass qualities can be obtained only from progeny tests and the progeny testing of beef bulls at frequent intervals is recommended.

Beef Cattle Section

C. W. Hickman, *Chairman*

THE PERFORMANCE OF UREA AS AN EXTENDER OF PROTEIN. H. M. Briggs, W. D. Gallup, A. E. Darlow, D. F. Stephens, and C. Kinney, *Oklahoma Agricultural Experiment Station.*

In a series of experiments, urea has been studied as a means or extending the available supply of protein supplement for beef cattle. The pellets used in these studies contained 10 percent blackstrap molasses, and the remainder of the pellets consisted of hominy feed, cottonseed meal, and crystal urea or Dupont's "262." Pellets in which 25, 50, 75, and nearly 100 percent of the supplemental nitrogen has been furnished by urea have been fed in metabolism stalls to yearling and two-year-old steers. Pellets containing no more than 50 percent urea nitrogen were staisfactory in metanolism studies as compared to cottonseed meal of the same protein content. Low grade prairie hay was used as the basal ration in the metabolism studies. Pellets containing 25 and 50 percent urea nitrogen have proven satisfactory as a source of supplemental protein in two dry lot studies with fattening calves. In two experiments pellets containing 25 percent urea nitrogen have given as satisfactory performance as cottonseed meal when fed to yearling heifers on the range. In one test pellets did not prove as satisfactory as cottonseed meal in wintering heavy steers under range conditions. No toxic effects of urea have been encountered when it has been used as a source of protein in the ration.

COPPER DEFICIENCY IN CATTLE. George K. Davis, R. W. Kidder, and C. L. Comar, *Florida Agricultural Experiment Station.*

Grade Devon cattle placed on unfertilized pastures of St. Augustine grass located in the Everglades developed evidence of copper deficiency within 60 to 90 days. Administration of copper sulfate solutions served to check the development of the deficiency symptoms. Adequate feed was available, as evidenced by the weight gains made with the feeding of copper supplements. Deficiency symptoms developed rapidly when copper was withheld. The cattle lost weight rapidly, severe scouring developed, the animals became gaunt, and the hair was bleached and coarse. Hemoglobin values dropped to 5–7 grams per 100 ml. and blood copper values to from 6 to 30 parts per 100 ml. Abnormal phosphorus metabolism was shown by the rickets-like swellings of the long bones and rarification and fracture of bones in older cattle. Blood inorganic phosphorus values remained normal. Response to copper supplements was rapid. Scours stopped in from 24 to 48 hours. Improvement in condition was noted within two weeks. Withdrawal of copper after all evidence of deficiency had disappeared resulted in the reinitiation of symptoms within 2 to 4 weeks.

FEEDING STIMULANTS TO BEEF CATTLE. M. E. Ensminger, E. A. Kline, and T. J. Cunha, *State College of Washington.*

Twenty-four head of long-yearling heifers grading good to choice are being used in feeding trials designed to determine the value of two stimulants, namely Fowler's solution (an arsenic compound) and Nuxvomica (strychnine compound) and Thiouracil. The animals are being full-fed identical rations consisting of barley, oats, beet pulp, peas, bran, alfalfa-grass hay, and minerals. Self-feeders are being used. The treatment of each lot of six heifers is as follows: Lot I, Control: Lot II, basal ration plus Fowler's Solution (18 grams arsenic trioxide per 1000 pounds grain); Lot III, basal ration plus Nuxvomica (300 grams Nuxvomica per 1000 pounds of grain); Lot IV, basal ration plus Thiouracil (2 pounds Thiouracil per 1000 pounds grain, or 0.2 percent of grain mixture). The effect, if any, from the use of the stimulants is being measured by the following criteria: Rate and efficiency of gain; carcass grade; thickness of fat over the eye muscle; the density, length, and luster of hair, the blood analysis (including vitamins A, C, and carotene; sugar; calcium, phosphorus, and red and white cell counts); and the physiological and pathological effects on the reproductive organs, heart, liver, kidneys, and thyroid glands. The following average daily gains were made during the first 70 days of the trial: Lot I, 2.29 pounds; Lot II, 3.10 pounds; Lot III, 3.15 pounds; and Lot IV, 2.70 pounds.

NEW DEVELOPMENTS IN THE BREEDING OF CATTLE ADAPTED TO TROPICAL AND SUBTROPICAL CLIMATES. Ralph W. Phillips, A. L. Baker and W. H. Black, *United States Department of Agriculture.*

Important developments in recent years include the following: (1) Practical demonstrations in India that animals carrying more than ½ to ¾ imported dairy blood (mostly Holstein) do not perform satisfactorily under conditions in India; (2) development of a relatively simple formula, in the Bureau of Animal Industry, for expressing in one figure the ability of an animal to maintain a low body temperature in a hot environment; (3) demonstration of marked differences between types in heat tolerances calculated by the formula, for example, zebu, 89; ½ zebu-½ Angus, 84; Angus, 59; (4) demonstration that light-colored coats reflect more sunlight and absorb less heat than darker coats; (5) demonstration of the superior ability of zebu×European hybrid cattle over European cattle for beef production in the Gulf-Coast Region and other similar areas such as northern Australia. A study of data on heat tolerance of animals with varying amounts of zebu or Africander and Angus blood has shown that there are significant variations among breeding groups, that dry cows have higher heat tolerances than cows that are nursing calves, that dry 2-year-olds have higher heat tolerances than yearlings, and that data on 2-year old heifers appear to be most useful for predicting heat tolerance as nursing cows at 4 and 5 years of age.

THE EFFECT OF THIOURACIL ON THE GROWTH AND FATTENING OF YEARLING STEERS. W. M. Beeson, F. N. Andrews, and P. T. Brown, *Purdue Agricultural Experiment Station.*

Five lots of 10 yearling Hereford steers averaging approximately 790 pounds were full fed for 154 days on a daily basal ration of corn and cobmeal 13.57 lb.; soybean oil meal, 2.23 lb.; corn silage 12.93 lb.; mixed clover timothy hay, 2.86 lb.; and access to loose salt and bonemeal. After 56 days thiouracil was incorporated in the soybean oil meal in quantities that would provide 2.0 gm., 4.0 gm. and 6.0 gm. of thiouracil per steer daily. One group of steers was given free access to thiouracil in the salt (1 to 10 parts by weight) for 28 days and for the remainder of period the thiouracil was fed in the bonemeal at the same ratio. By either method of feeding the thiouracil intake was only 0.11 gm. per steer daily. Thiouracil intakes of 2.0 to 6.0 gm. per steer per day did not depress the rate of growth; instead the rate of gain appeared to be slightly increased in the groups receiving 2.0 gm. and 4.0 gm. thiouracil daily. Feed consumption was not depressed by the addition of 2.0 to 6.0 gm. of thiouracil to the daily ration. There was a tendency for the steers receiving 2.0 and 4.0 thiouracil to require less feed per pound of gain. Thyroid weight was increased 50 percent in steers receiving 4.0 gm. of thiouracil daily and final thyroid size was not affected by the consumption of 2.0 gm. thiouracil daily for 98 days. Dressing percentage and degree of finish were not significantly affected by thiouracil.

BLOOD ANALYSES AND OTHER OBSERVATIONS ON BEEF CATTLE AFFECTED WITH GENERALIZED EDEMA OR ANASARCA DUE TO VITAMIN A DEFICIENCY. Louis L. Madsen and I. P. Earle, *United States Department of Agriculture.*

Statistics are presented showing that a total of 590 beef carcasses were condemned for generalized edema or anasarca by Federal meat inspectors during the period of July 1941 to April 1946 inclusive. Others symptoms of vitamin A deficiency were found to be prevalent among cattle with anasarca in the Corn Belt area. The condition was observed to occur in cattle after a long fattening period in dry lot when fed either stored or new corn in combination with a roughage of low carotene content such as oat hay or straw. Alfalfa hay was highly effective in curing the condition. It is concluded, therefore, that the major dietary error in the production of this deficiency disease is the exclusive use of low-carotene roughages throughout the feeding period rather than the age of the yellow corn fed. Cases of anasarca were readily produced experimentally by feeding a carotene deficient ration or a grain ration containing 80 percent of new crop or yellow corn together with oat straw as roughage. Results of blood studies made on field and experimental cases of anasarca produced by vitamin A

deficiency indicate that the two conditions were identical. The principal blood findings in affected animals as contrasted with normal values were: (1) Deficiency levels of blood plasma vitamin A and carotene and a decrease in plasma vitamin C as the vitamin A deficiency progressed, (2) an increase in total plasma globulin due usually to a marked increase in plasma fibrinogen with smaller increases in the other globulin fractions, (3) some decrease in plasma albumin, and (4) an increase in total plasma nitrogen with no significant change in the nonprotein nitrogen fraction. Serum-calcium and inorganic phosphorus decreased slightly in anasarca, but the average values stayed within the normal range; however, phosphatase activity of the serum was significantly reduced. Serum magnesium was relatively unchanged.

THE DIGESTIBILITY OF PRAIRIE HAY OF VARIABLE COMPOSITION WITH SOME OBSERVATIONS ON THE FECAL-NITROGEN EXCRETION OF STEERS IN RELATION TO THEIR DRY MATTER INTAKE. Willis D. Gallup and H. M. Briggs, *Oklahoma Agricultural Experiment Station.*

Results are reported for twenty digestion trials in which steers were fed prairie hay of variable composition, alone, and supplemented with varying amounts of cottonseed meal. The purpose of the study was to investigate the apparent relationship between the proximate composition of prairie hay and its nutritive value. Total digestible nutrients of the hay increased in a fairly uniform manner from 41 to 56 percent as the protein content of the hay increased from about 3 to 6 percent. In like manner crude fiber digestibility increased from 56 to 69 percent while the apparent digestibility of protein increased from negative values to 41 percent. When cottonseed meal in amounts varying from 0.5 to 3 lbs. daily was fed as a supplement to 10 lbs. of hay, differences in digestibility related to the protein content of the hay were again apparent. The digestibility of dry matter in the high protein hay was equal to that in rations made up of average or low protein hay supplemented with two pounds of cottonseed meal. Wastage of protein in digestion expressed as nitrogen lost in the feces per 100 grams of dry matter intake, varied only slightly from 0.55 gram when hay was fed alone, and increased from 0.60 to about 0.80 gram when increasing amounts of cottonseed meal were fed as a supplement. A close relationship between protein content and digestibility of nutrients in hay is indicated in these results.

SKELETAL ABNORMALITY OF PROBABLE NUTRITIONAL-ENDOCRINE ORIGIN OBSERVED IN CATTLE RECEIVING ANTIRACHITOGENIC RATIONS. L. E. Washburn, *Colorado A & M College.*

A condition characterized by simple or multiple symptoms including lameness, crooked feet and legs, fragile bone, soft and eroded bone articulation surfaces, and occasionally sterility, has been observed frequently in cattle which were fitted for show on nurse cows. Careful inspection of rations has eliminated calcium or vitamin D deficiencies or calcium-phosphorus imbalance as causative factors. That sex factors may be involved appears to be indicated by the fact that males are highly susceptible while heifers and steers are less frequently affected. A preliminary investigation with rats fed similar rations showed consistently a rather marked reduction in thyroid gland weight as a result of heavy milk intake. The thyroid gland reduction, which was believed not to be an iodine effect, was prevented by supplementing the ration with approximately 30 p.p.m. of copper. No such inhibitive action was observed upon feeding iron or manganese. When copper was fed at a level of about 15 p.p.m. to bulls on nurse cows, the symptoms described above failed to occur. Moreover, the animals were more alert and active and presented a more desirable show appearance.

THE BLOOD PHOSPHORUS LEVELS NECESSARY FOR SATISFACTORY PRODUCTION OF RANGE CATTLE IN THE SOUTHWEST. W. E. Watkins and J. H. Knox, *New Mexico Agricultural Experiment Station.*

One group of Hereford cows was fed a dicalcium phosphate-salt mixture while another received only salt. Forage samples were gathered at 28-day intervals and their analyses com-

pared with the inorganic phosphorus of the blood plasma. The phosphorus in the forage, except during the growing season, was below that required by breeding cows. The inorganic blood phosphorus was closely related to the apparent phosphorus intake. The estimated phosphorus intake, including the mineral supplement, averaged nearly 12 grams daily and the inorganic plasma phosphorus fell below three milligrams for only short periods. The average weigl.t of calves weaned in the mineral fed group was 469 pounds while the control group was 430 pounds. The excellent health and superior production of these mineral fed cows during this experiment indicate that such levels of phosphorus intake and such blood pictures are not inconsistent with good health and production for mature cows in the southwest.

In another experiment, range cows fed bone meal and salt only during the critical spring months were compared with cows fed bone meal continuously. The blood analyses showed that the seasonally fed nurse cows obtained less than the needed amount of phosphorus for a considerable part of the time when no supplement was fed. Continuous mineral feeding resulted in more calves being raised to weaning age.

THE ACCURACY OF ONE-DAY AND THREE-DAY WEIGHTS OF CALVES. A. L. Baker, Ralph W. Phillips and W. H. Black, *United States Department of Agriculture*...

Weights obtained during 1943–44–45 on 178 crossbred calves were used in the study. The calves ranged in age from 177 to 283 days and averaged 231.6 days, when weighed. Weights were taken on 3 consecutive days and calves were weaned after the third weighing. On the day preceding the first weighing, cows and calves were moved to a pasture within ¼ mile of the scales, and were kept there until weighings were completed, except for movements to and from scales. A 10-ton double-beam pit scale was used and weights were taken to the nearest 5 pounds. Averages and standard errors for the first, second and third weights, and for the 3-day average, were, respectively, 425.93 ± 4.76, 424.97 ± 4.76, 422.89 ± 4.77 and 424.60 ± 4.75. The 3-day average did not differ significantly from the first-day weight. After dividing into weight classes, with 20-pound intervals, the standard errors of single and 3-day weights were compared. In fourteen classes having 4 to 23 animals each, the standard error was lower in the first-day weights in all classes than in the second and third-day weights and in the 3-day average. The standard error of the 2nd-day weight was lower than that of the 3rd-day weights in nine of the 14 classes. These results indicate that there is no advantage in taking weights on three days, compared with a single weight, under the uniform conditions of this test.

THE COMPARATIVE EFFICIENCY OF SINGLE VERSUS THREE-DAY WEIGHTS OF STEERS. R. E. Patterson, *Texas Agricultural Experiment Station.*

Variances for initial and final weights and for gains are segregated into their components. The variations due to errors in weighing constitute about 0.40 percent of the variance between animals for three-day initial weights and about 1.18 percent for single-day initial weights. Corresponding values for three-day final and single-day final are 0.33 percent and 0.97 percent, respectively. The reduction of the experimental error due to two extra weighings is thus 0.79 percent for initial weights and 0.65 percent for final weights. The variations due to errors in weighing constitute 1.16 percent of the variance between animal gains based upon three-day weights, and 3.41 percent for single-day weights. The reduction in the variance between animals (experimental error) due to the four extra weighings is thus 2.27 percent. The reduction for two-day weights is 1.70 percent, and the reduction of the variance of three-day weights over two-day weights is 0.58 percent. The precisions gained by weighing more than once at the beginning and end of a test can be relatively costly. In these experiments the same degree of precision as obtained from three-day weights would have been expected from single-day weights if the number of animals had been increased 2.32 percent. Thus, data from 103 animals with single-day weights would be expected to be slightly more efficient than those from 100 animals with three-day weights.

Dairy Cattle Section

J. H. Hilton, *Chairman*

EFFECT OF THE LEVEL OF PROTEIN IN THE PREPARTUM RATION OF DAIRY HEIFERS AND COWS ON THE DEGREE OF MAMMARY EDEMA. G. H. Wise, F. W. Atkeson, M. J. Caldwell and J. S. Hughes, *Kansas Agricultural Experiment Station.*

There is a widespread belief that feeding rations consisting primarily of carbohydrate feeds, corn particularly, to heifers and cows during the latter stages of gestation is conducive to the development of congestion and edema in the mammary system. Two rations markedly different in protein content were fed to comparable groups of animals during the terminal two months of gestation and the first week of lactation to determine the effects of these diets on the degree of mammary edema. One group of five heifers and five cows was fed a low protein ration consisting of corn, sorghum silage and prairie hay; while a similar group was fed a high protein ration consisting or a concentrate mixture (approximately 25% protein), sorghum silage and alfalfa hay. The system of feeding, grain at the rate of one pound per 100 pounds body weight and roughage in the ratio of 3 pounds of silage to 1 of hay to the extent of the appetite, was the same in the two groups. The incidence of edema revealed no significant difference that could be attributed to the rations. The degree of edema as determined by palpation and by macroscopic examination tended to be somewhat greater in the low protein group, but this is of doubtful significance in view of the extreme individual variability within each group. As commonly noted, the severity of the edema was more pronounced in heifers than in cows. The time of development also was variable—ranging from several weeks prepartum to several days postpartum. These observations suggest that factors other than dietary constituents probably play a more significant role in the incidence and degree of edema.

HOW IS MILK SECRETION INITIATED AT PARTURITION? Joseph Meites and C. W. Turner, *Missouri Agricultural Experiment Station.*

The mechanism responsible for the onset of lactation at parturition has long been a mystery to physiologists and animal husbandrymen. Early workers viewed lactation as a passive phenomenon which was initiated with the removal of certain inhibitory agents at parturition. In the last 20 years it has been established that lactation is under the control of the endocrine system, and that a central role is played by the pituitary lactogenic hormone. The growth of the mammary glands has been shown to be complete and ready for secretion about the one-half to two-thirds of pregnancy. The pituitary lactogenic hormone, however, remains low during most of pregnancy and begins to increase only a short time prior to calving. Following parturition, pituitary lactogen rises precipitously to a peak 200 to 400 percent above the pregnancy level. Experimentally, only estrogen has been shown capable of greatly increasing pituitary lactogenic hormone and initiating lactation in virgin animals. We believe this hormone is responsible for initiating milk secretion at parturition. During pregnancy both estrogen and progestin are secreted in increasing amounts. Almost until term progestin is dominant over estrogen, thus maintaining pregnancy. A short period prior to calving, however, estrogen is believed to gain the ascendency over progestin and play a role in the initiation of calving as well as lactation. It is believed that at this period estrogen precipitates the great rise in pituitary lactogenic hormone, thus initiating milk secretion. Considerable experimental data have been accumulated to support this theory.

CHOLINE STUDIES WITH YOUNG DAIRY CALVES. R. K. Waugh, S. M. Hauge, and W. A. King, *Purdue Agricultural Experiment Station.*

Studies were made to determine the effect of age and feeding of milk upon the choline content of blood of young calves. At birth the blood choline was found to be comparatively low, eleven calves averaging 0.19 mg. of choline per ml. of whole blood. The blood level of the calves fed milk increased to 0.25, 0.31, and 0.34 mg./ml. at the end of one, two, and three weeks respectively. After this period the values tended to level off. Calves fed milk maintained the

higher blood choline levels, whereas removal of milk from the diet of calves at 35 days of age was accompanied by a definite decrease in the choline content of the blood. Present data indicate that the administration of choline chloride was not effective in restoring the higher choline values of the blood. Colostrum was found to be high in choline averaging about 0.70 mg./ml. for the first milking. These values decreased rapidly to about 0.16 mg./ml. at the sixth milking and 0.13 mg./ml. at the end of one week.

THE INFLUENCE OF QUANTITY AND QUALITY OF NUTRIENTS ON THE GROWTH OF DAIRY HEIFERS. H. A. Herman and A. C. Ragsdale, *University of Missouri.*

Three systems of management and feeding were used in growing dairy heifers. One group of 5 Holstein heifers received wholemilk the first 3 weeks of age, thereafter skimmilk to 9 months of age, with chopped alfalfa hay of good quality plus salt and steamed bone meal forming the only roughage supplement to 9 months of age and the entire diet thereafter to freshening age. A second group (24) was raised on a special "Rapid Growth Ration," which contained 26.5 percent crude protein and 72 percent T.D.N. It was fed ad libitum (as was the chopped alfalfa) and wholemilk (3.8 percent fat) was fed at the rate of 16 to 20 pounds per day until freshening time. A third group (10) served as controls. They were fed wholemilk the first 3 weeks of age, changed to skimmilk feeding until 4 to 5 months of age and received leafy alfalfa and clover hay and a grain mixture of oats, corn, bran, protein supplement, salt and bonemeal to 7 to 9 months of age. Thereafter they were raised largely on roughages (legume hay) and pasture with limited grain feeding 6 to 8 weeks prior to freshening. The heifers in group I were lighter in weight and smaller than the heifers in group II or group III. The heifers in Group I freshened normally at 27 months of age. They produced 6710 pounds of milk, 261 pounds of butterfat in 338 days. The controls averaged 7991 pounds milk, 301 pounds fat in 305 days 2 times milking. The heifers in group III averaged 7721 lbs. milk and 292 lbs. butterfat. Their production was disappointing and remained so for the second and third lactation. A few of the heifers developed heavy, meaty udders.

The entire group was characterized by a heavy, coarse build with a great deal of fat deposition in the udder before freshening. This experiment illustrates the point that overfeeding and over fitting of dairy heifers is objectionable and costly. An alfalfa-skimmilk diet does not provide sufficient energy for maximum growth. The most desirable heifers are produced by a feeding program of milk the first few months, supplemented with grain and good hay and after 8 to 9 months heavy roughage feeding with minimum grain.

SOME FACTORS AFFECTING THE TOXICITY OF COBALT IN THE BOVINE. Ray E. Ely, Kenneth M. Dunn, C. W. Duncan, and C. F. Huffman, *Michigan Agricultural Experiment Station.*

The essentiality of minute quantities of cobalt in the ration of the ruminant has been amply demonstrated. However, the ease and likelihood of administering many times the requirement makes a knowledge of toxic levels and factors affecting cobalt toxicity in the bovine of prime importance. Wide variations in the tolerance of individual animals to relatively high doses of cobalt salts have been observed. Detrimental effects to appetite have occurred in lactating animals with single dosages of from one to five grams of cobalt sulfate, while two young males have tolerated daily doses of ten grams cobalt sulfate for 90 and 127 days. Calves fed 500 mg. of cobalt equivalent in the form of cobalt sulfate, cobalt chloride or cobalt carbonate showed no difference in the length of time for reduced appetite to occur. Intravenous injections of from 0.5 to 0.6 mg. cobalt per pound of body weight gave symptoms of rapid respiration, incoordination, lacrimation, salivation, defecation, and urine leakage within one to five minutes after injection. These symptoms were prevented by intravenous injections of 4 mg. methionine per pound of body weight immediately preceding the cobalt injections. The effect of different levels of protein in the ration of the toxicity of cobalt when administered orally is being studied.

MILK PRODUCTION AS RELATED TO AGE IN HOLSTEIN-FRIESIAN COWS
Robert R. Shrode, *Iowa State College.*

When age correction factors are derived by comparing the production averages of successive age groups, they can be biased by the effects of selection. The advanced age groups consist of cows which are not only older but also are the survivors of whatever culling of low producers was done at earlier ages. To keep such selection from biasing age correction factors, the change in production with increasing age was studied on pairs of consecutive records from the same cow. Ratios of production at each monthly age level to production of the same cows twelve months earlier were computed. Moving averages and multiple regression methods were used to fit smooth curves to such ratios. The data included 43,573 yearly records made by approximately 11,000 Holstein-Friesian cows on the Herd Improvement Test. Separate curves were fitted to records made on twice-a-day and those made on thrice-a-day milking. The ratio of 2× to 3× production seems not to be constant at ages below 36 months. At ages older than 36 months no obvious trend in the 2×:3× ratio with changes in age could be observed. At ages over 36 months the data confirm the widespread practice of considering this ratio as 5:6.

THYROXINE SECRETION RATE IN THE ALBINO MOUSE. V. Hurst and C. W. Turner, *Missouri Agricultural Experiment Station.*

Koger and Turner (Mo. Research Bulletin #377) have shown that the growth rate of young female mice can be stimulated by about 25 percent by the daily injection of d,l-thyroxine at the rate of 100 to 200 micrograms per 100 grams body weight and in young male mice at the rate of 200 micrograms per 100 grams body weight. It would be of great interest to know how this dosage of thyroxine compares with the average daily secretion rate of the mouse thyroid. Recently, Schultze and Turner (Mo. Research Bulletin #392) worked out a method for the determination of the thyroid secretion in terms of d, l-thyroxine. Applying this method during the summer of 1946, it was observed that the adult female mouse secretes at the rate of 3 to 4 micrograms of d,l-thyroxine equivalent per 100 grams of body weight per day and the male mouse from 0.5 to 1 microgram. The sex difference indicated by this study is under further investigation. Bearing in mind the rise in metabolism during pregnancy and lactation and the fact that the administration of thyroprotein will increase milk secretion in certain species, the rate of thyroid secretion during these processes is being followed with great interest.

AN INHERITED SENSITIVITY TO MILKING ENVIRONMENT THAT MARKEDLY AFFECTS MILK PRODUCTION. W. E. Petersen and L. O. Gilmore, *University of Minnesota.*

Evidence has been obtained that unusual sensitivity to milking conditions in a cow family was responsible for sharp declines in the lactation curve and in total milk yield. The involved individuals failed to respond to the milking stimulus with a let down of milk which fact is responsible for the premature drying off. One cow (248) was observed for 5 lactations. During the first lactation she presented a normal lactation curve milking 340 days when dried off for a rest period. In the 2nd, 3rd and 4th lactations, she was apparently maladjusted and except for occasional milkings did not respond with a complete let down of milk. Other cows under the same environment responded normally. In the fifth lactation she was milked by a special milker to whom she was adjusted and milkings were normal except for two one-week periods when another milker was used. During these two weekly periods she returned to her former idiosyncracy. In the 5th lactation she produced 61.2 percent more milk than in any but her first lactation. This cow has three daughters, two of which present the same sensitivity to the milking environment and the third is normal. Inspection of the dam's performance indicates she too possessed the same characteristic but not so pronounced. A granddaughter out of one of the two affected daughters apparently is normal. This also is true of a maternal sister.

COMPARISON OF FIELD-CURED AND MOW-CURED BALED ALFALFA HAY FOR MILK PRODUCTION. S. M. Hauge, W. A. King, J. W. Wilbur, and R. C. Shipman, *Purdue Agricultural Experiment Station.*

A comparison of field-cured and mow-cured baled alfalfa hay was made with two groups of six milking cows each. The feeding trials were conducted for periods of 9 weeks each for all three cuttings. The results of one year's experiments indicate no significant difference between the two methods of curing hay in either gains of live weight or milk production. The cows were fed the respective hays as the only roughage and grain according to milk production. The carotene content of the first cutting hay, as fed, was 10 and 13 micrograms per gram of dry matter for field-cured and mow-cured hay respectively; 9 (low due to adverse weather conditions in curing) and 25 micrograms for second cutting; and 25 micrograms for each of the curings of third cutting. It appears that mow curing of baled hay does not retain the carotene in hay much better than field curing when the field curing conditions are not too adverse. As would be expected when no great differences are found in the carotene content of the hays, no significant differences between the blood carotene and vitamin A potency of the butterfat produced by the cows fed the first and third cutting hay were found. Considerable more carotene was found in the blood of the cows fed the second cutting mow-cured hay than in those fed the field-cured. Butterfat of much greater vitamin A potency was produced by the cows of the former group.

THE ANDROGENIC (MALE) HORMONE CONTENT OF DAIRY CATTLE MANURE. C. W. Turner, *Missouri Agricultural Experiment Station.*

In 1942 Riley and Hammond reported upon the feeding of dried cow manure to baby chicks. They noted a precocious growth of their combs and other head appendages. Further study indicated the presence of considerable amounts of androgenic hormone in cow manure which was orally available to chickens. In this laboratory we have confirmed the above observations in regard to the presence of and excretion by dairy cattle of rather large amounts of male hormone. In contrast, dairy goats, sheep and dairy bulls appear to excrete only very small amounts of this hormone. Male hormone has been observed to stimulate growth in rats and increase nitrogen retention in clinical studies in man. The feeding of dried lactating cow manure in amounts from 2½ to 20 percent of the ration of White Plymouth Rock pullets has been observed to stimulate growth above that of controls. Further, up to 10 precent of the ration, the inclusion of cow manure did not inhibit sexual maturity or the initiation of egg laying. While cow manure has been recognized for some time as a source of considerable amounts of vitamins of the B-complex, and a good substitute for alfalfa meal in poultry rations, the possible growth-stimulating properties of the androgenic hormone upon females is a new observation which deserves further study in growing livestock. In preliminary trials with castrate rats, mice, and male goats, the androgenic hormone in cow manure has been shown to be orally effective in mammals as well as birds. In growing swine the use of dried lactating cow manure in the ration would furnish a good source not only of the B-complex vitamins but probably of male hormone as well.

THE EFFECT OF PENICILLIN UPON THE LIVABILITY, FERTILITY AND BACTERIAL CONTENT OF BULL SEMEN. J. O. Almquist, W. T. S. Thorp and C. B. Knodt, *Pennsylvania Agricultural Experiment Station.*

The control of bacterial flora in diluted semen is important in artificial breeding. In an effort to minimize this problem, penicillin was added to each of 12 samples of bull semen diluted 1 to 24 with yolk-citrate at the rate of 0, 250, 500, 750, 1000, 1250, 1500 and 2000 Oxford units per ml. of diluted semen. The samples were stored at 40° F. and motility estimations were made every 2 days for 20 days. Analysis of variance involving a total of 960 motility estimations showed no significant difference in livability at the 0, 250, 500 and 750 levels. The 1000 to 2000 unit levels showed a highly significant decline in the ability of the spermatozoa to maintain motility. For the first 6 days of storage there was no decrease in livability

during this period except in the 1250, 1500 and 2000 unit levels. Analysis of variance of all data demonstrated that penicillin significantly reduced glucose utilization while the amount of lactic acid produced showed no statistically significant differences compared with controls after 8 and 16 days storage. Blood agar plate counts indicated that penicillin retards bacterial growth at all levels tested. After 8 days storage at 40° F. penicillin assays showed no less in penicillin activity while there was only a slight decrease in concentration after 16 days. To determine the influence on fertility a Latin square experiment was designed using the 500 and 1000 unit levels with appropriate controls. Data based on one month's non-returns of 5,212 first and second service cows indicates that these levels of penicillin do not appreciably affect fertility.

THE EFFECT OF THYROPROTEIN (PROTAMONE) ON MILK PRODUCTION AND ON SOME OF THE CONSTITUENTS OF THE MILK AND BLOOD OF DAIRY COWS. J. W. Hibbs and W. E. Krauss, *Ohio Agricultural Experiment Station.*

The feeding of protamone at the rate of 1 gram per 53 pounds of body weight daily for two controlled six-week periods resulted in the following observations: (1) An average increase in milk production, which was dependent upon the nutrient intake of the cow. This increase was followed by a rapid decline to a subnormal level after termination of protamone feeding; (2) A decrease in body weignt and increases in pulse and respiratory rates; (3) No changes in milk or blood plasma carotene or ascorbic acid. A few individual cows showed decreases in milk and blood plasma vitamin A. Although suggestive these results were not conclusive; (4) A decrease in milk thiamin during protamone feeding and an increase to higher than normal levels following the termination of protamone feeding (5) Lowering of milk riboflavin during the experimental period, the most marked effect being observed during the period in which the nutrient intake was limited; (6) No effect on total milk protein; (7) No significant elevation in basal metabolic rate of rats fed exclusively on milk from protamone fed cows. In view of these results great care should be exercised in feeding protamone to dairy cows. The greatest possibility for its use in dairy cows may lie in the treatment of hyperthyroid individuals rather than in general feeding to all milking cows in the herd.

THE VALUE OF A STATE FEDERATION OF DAIRY CATTLE ARTIFICIAL BREEDING ORGANIZATIONS. H. A. Herman, A. C. Ragsdale, M. J. Regan and E. T. Itschner, *University of Missouri.*

A recognized need for a central organization or federation of dairy cattle artificial breeding organizations has been partially solved by forming of "The Missouri Federation of Artificial Breeding Organizations." This federation was formed early in 1945. Its objectives are: (a) Integrating all organizations into a State program and strengthening member organizations; (b) To make possible the fullest utilization, on a practical basis, of artificial breeding as a means of improving our dairy herds in this State; (c) To secure cooperation of all interests concerned in developing and guiding artificial insemination in this State into sound, approved, financially stable channels; (d) To provide a means of keeping bulls in use until they are proved and to lower the sire cost per operating unit; (e) To disseminate information concerning latest techniques and developments dealing with artificial insemination of dairy cattle; (f) To develop and foster a spirit of fair play and understanding concerning territories, charges, and business procedure as it concerns artificial insemination. A list of the sires in use in each organization is kept on file. As bulls are retired, or as they are no longer needed in one organization the fact is made known to other organizations and this helps establish a "bull pool" where sires may be purchased or exchanged. All sires are subjected to close scrutiny by a sire committee before they are purchased or leased by any organization member of the federation. A list of approved inseminators is kept for each organization. Two short courses are held each year at the Missouri College of Agriculture to train new men in the technique of artificial insemination of dairy cattle and also to acquaint inseminators in the field with new developments. An examination is provided for at the close of each course and every approved inseminator must attend at least one such course and make a passing grade on examination.

Extension Section

L. A. Richardson, *Chairman*

DEVELOPMENT OF A COUNTY SWINE PROGRAM. W. H. Bruner, *County Agricultural Agent, Preble County, Ohio.*

The swine program is in charge of a sub-committee of the Preble County Livestock Committee. It has been developed through cooperation with Pure-bred Breeders' Ass'n, Pure-Line Breeders' Ass'n, 4-H Clubs, County Banks and cooperative Marketing Agency. Annual sales of boars and gilts have been held since 1940 with most consignments going into farm herds. Pure-bred breeders organization sponsors 4-H swine projects. Sow testing and barrow-carcass cut-out study inaugurated in 1945 revealed wide variation in live weight value, fat back thickness, percent of trimmed loin, ham, shoulder, and bacon. This led to 1946 project in which 42 litters were weighed on farms. Two representative pigs from 20 litters were placed in a central feeding station on County Fairgrounds. All pigs entered feeding test free of disqualifications of Ohio Swine Improvement Program and met litter size and weight requirements of Breed Production Registry. Litter samples were fed from 70 days of age to 210 pounds. The study considers (1) Indurability; (2) Productiveness; (3) Nursing ability; (4) Gaining ability, (5) Efficiency of feed utilization; (6) Freedom from defects; and (7) Quality of carcass or value of product. Litters qualify as "Commercial," "Approved," "Certified" and "Proved." This study is an effort to discover desirable breeding stock that will enable farmers to produce efficiently the most valuable hog carcass. The program is divided into three phases; (1) Educational and factual; (2) Source of desirable breeding stocks; (3) Marketing program that will reflect to farmers the differences in value of hogs of different types.

TAKING A PRODUCTION PROJECT TO MARKET. W. B. Connell, *Pennsylvania State College.*

The dividing line between production and marketing is rather indefinite. The most effective kind of extension teaching is that which directly reaches the producer's pocketbook. Any livestock extension project that follows through from the grass roots to the market usually meets with the cooperation of the farmer. In 1919 the livestock extension division of the Pennsylvania State College started a lamb and wool improvement program. This program has been conducted in cooperation with the 32 Sheep and Wool Growers' associations. These organizations are each managed by a board of nine farmer directors and have handled wool for growers in 51 counties out of the 67 counties in the State. The wools are graded at the loading point in each county or district, thus giving each farmer an opportunity to learn what the market demands. The effectiveness of this kind is teaching is proven by the fact that the percentage of off-grade wools has been reduced from 18 percent to 6 percent. These associations sponsor the sheep improvement program in the county. Some cooperative lamb marketing has been done by these organizations as well as sponsoring ram sales and ram trucks. Four hundred and ninety-five rams were placed with Pennsylvania farmers through these organizations. Five thousand pounds of phenothiazine powder was distributed to the growers by these 32 associations during 1945. This wool and lamb marketing project has given the extension service an effective contact with the sheep growers.

REFRESHER ACTIVITIES FOR COUNTY AGENTS AND LOCAL LEADERS. Paul F. Newell, *Mississippi State College.*

Most land-grant college graduates come to Extension lacking practical experience and training in fields that fit them for the job because teaching personnel have had insufficient extension experience to handle courses in extension methods and technique. Also, during the war many experienced county workers were replaced with men inexperienced in extension work. Therefore, refresher activities and tours were developed to remedy this situation, as applied to animal husbandry. These tours have been used as a plan of extending the training

of our workers. As early as 1937 a type of inservice training was initiated, but best results were not obtained because needed facilities, animals and equipment were not available. By 1944, three one-day meetings, with programs including a maximum use of demonstrations, were held in areas with a concentration of livestock interest. Problems in these one-day meetings included animal selection, principles of feeding, demonstrations in fitting and training animals for show and sale and livestock management demonstrations. In 1945, the plan was based on supervisory agents' districts, with two days spent in each. The only major change made in 1946 was that plans were based on type of farming areas rather than on extension districts. The tours, held in April, permitted emphasis on pasture, forage and feed production in the development of successful livestock programs and enterprises. The aim in these refresher courses has been to bring returning servicemen and new agents up-to-date on changed conditions. A broadened interest in our livestock program was observed and results prove that worthwhile accomplishments were made. The cost per agent in 1945 was $10.49 and in 1946, $10.

Horse and Mule Section

R. E. Hunt, *Chairman*

CROSSBREEDING LIGHT AND HEAVY HORSES. R. S. Hudson, *Michigan State College.*

The initial step in a program to study cross-breeding light and heavy types to learn the adaptability of the offspring as compared with purebreds, began in 1939 with the purchase of 28 foals from medium and heavyweight draft mares and stallions. They were fed until three years of age on different planes of nutrition, some with and without grain, chore labor and housing. The general conclusion at the end of this period was that (1) colts may be grown in the open without grain but that (2) they maintain more vitality to withstand attacks of influenza, etc., as foals if fed some grain. (3) Absence of grain does not affect their final development if given plenty of forage both winter and summer and (4) colts of part draft blood carry more flesh and have greater resistance to cold and disease than light legged colts. The second phase of the study began in 1942 when four three-year-old fillies from the feeding project were mated with an Arabian stallion and two years later to a Thoroughbred stallion. Two of the mares selected were considered heavyweight drafters and the other two lightweight drafters. One of the heavyweight mares was developed in the field both winter and summer without grain and labor. Colts show: (1) More refinement from the two lightweight mares in both the Arabian and Thoroughbred crosses. (2) More popular colors and greater refinement in the Arab crossbreds. (3) More weight and ruggedness in the Thoroughbred crosses. (4) Sharper withers, longer necks and more height in the Thoroughbred cross. It is yet too early to draw definite conclusions, for the Arabian colts being older and more mature naturally show to an advantage in comparison with the younger cross-breds from the Thoroughbred mating.

A NATION WIDE VIEW OF THE HORSE AND MULE INDUSTRY. Wayne Dinsmore, *Horse and Mule Association of America, Inc.*

Pleasure horses are prospering. Work stock is in the doldrums, with very little demand save purchases for UNRRA for export. Prices on animals bought for UNRRA have been so low they have depressed the prices offered for better work stock and have discouraged breeding. About 90,000 horses, chiefly mares, have been bought and shipped up to September 5th, 1946 and about 60,000 more are to be purchased and shipped for distribution by UNRRA before the end of 1946—a total of about 150,000 head. Earliest contracts ranged from $85.00 to $100.00 per head—later contracts were still lower. All deals were F.O.B. cars at inland shipping points. Farmers got only from $40 to $65 per head for good work animals. Mules continued in strong demand at good prices, due to steady purchase for southern farm use.

Shortage of labor on farms and high wages have been the principal reasons for the decline in use of work horses. During 1943, 1944 and 1945 many farms were virtually stripped of young men by draft or voluntary enlistments and by war plants. Farmers used tractors more and horses less. A man would use a tractor only, for 14 or 16 hours a day because he was trying to do as much alone as he and a hired man formerly did with horses. Few work mares were bred in 1943, 1944, 1945 or 1946. Even mule production declined greatly. Exports, even up to 250,000 head, and the slaughter of 150,000 more for meat and pet food, is not apt to have any material effect upon horse breeding and use as long as prices for farm products and labor remain high. A severe drop in farm prices will cause men to use horses and mules. No one knows when prices for grains and other farm products will go down, but they have always gone down after every great war, and there is no reason to believe the present year is an exception.

Meats Section

B. W. Gardner, Jr., *Chairman*

EFFECT OF TEMPERATURE OF FREEZING ON HISTOLOGICAL CHARACTERISTICS AND TENDERNESS OF BEEF. R. L. Hiner and O. G. Hankins, *United States Department of Agriculture.*

Tenderness of beef was found to be favorably affected by reducing the temperatures for freezing. Histological examination of frozen sections from 1.5 inch cubes of longissimus dorsi muscle frozen at 18° F. showed large interfibrillar ice crystals which had pushed the fibers into distorted groups. No intrafibrillar ice crystals were visible. As freezing temperatures were lowered, the ice crystals became smaller and more numerous, with the first intrafibrillar ice visible as a result of 0° F. freezing. Fiber splitting was observed in longitudinal sections at −10° F. and was more and more extensive as freezing temperatures were lowered to −114° F. In other work 40- to 45-pound beef rounds from Choice to Commerical grade carcasses were used. Freezing was done in still air at temperatures of +18°, 0°, −15°, −40°, and −114° F. Series of longitudinal and cross-section samples were sectioned at 25 millimeter intervals, from the exposed surface to the center of the round, a distance of approximately 150 millimeters. The photomicrographs showed that the largest crystals were near the surface and the smaller more numerous crystals near the center. This was true for each temperature studied. However, in general the crystals in rounds frozen at 18° were larger than in those frozen at 0°, and so forth with decreasing temperatures. No fiber splitting or intrafibrillar ice crystals were observed in rounds frozen at +18° F. At the lower freezing temperatures fiber splitting was found in longitudinal sections and was increasingly extensive as temperatures were lowered to the extreme of −114° F.

Nutrition Section

J. L. Krider, *Chairman*

AN UNIDENTIFIED NUTRIENT IN FOODS AND FEEDS. A. M. Hartman, L. P. Dryden, G. D. Likely, and C. A. Cary, *United States Department of Agriculture.*

Evidence of unidentified nutrient (X) in milk, skimmilk powders, cheese (Cheddar, Swiss, cottage), beef muscle, pork muscle, egg yolk, liver extracts and leafy foods and feeds (lettuce, timothy, alfalfa, blue grass) and not in white, enriched or whole wheat flour or in wheat bran, corn meal, soybean or linseed oil meals, or in yeasts or coagulated egg white will be presented. Diets (C), adequate in all known nutrients (including pterolyglutamic acid), may be deficient in X. Young rats, reared by mothers fed C, are so depleted when weaned that, if they are then fed C containing 25 percent and 26 to 30 percent of that of their sex-litter mates receiving the same diet plus X; and with C containing 65 percent of protein death has generally occurred within 14 days, whereas sex-litter mates fed this 65 percent protein diet plus X have grown well. Similar results were obtained when C contained dextrin, C. P.

dextrone, or 10, 25 percent or 50 percent of fat; but with 25 percent of lactose in C the growth rate was only 37 percent of that of sex-litter mates on same diet plus X. Feed intakes on C were decidedly reduced, both the fat-free dry weights and fat contents of the carcasses were low, kidneys were hypertrophied, sexual development delayed, gestation failures frequent, number of young in litters and percentage weaned reduced, and animals frequently ceased to grow at markedly subnormal weights. X is effective when administered separate from C either per os, subcutaneously or intramuscularly. Preparations of X have been made that were active in daily doses of a few micrograms.

EFFICIENCY OF UTILIZATION OF FOOD ENERGY IN RELATION TO THE FAT CONTENTS OF RATIONS. E. B. Forbes and R. W. Swift, *Pennsylvania State College.*

Experiments having been conducted with albino rats as subjects, on rations containing 2, 5, 10 and 30 percent of fat, these rations having been so compounded and fed as to supply identical amounts of gross energy and of protein, and having shown that the efficiency of utilization of food energy was in the order of the increasing fat contents of these diets, further experiments of the same character were conducted, with greatly increased allowance of 10 vitamins, which confirmed the earlier conclusion stated. Attention is called to a new solvent process of treatment of cottonseed meal which is expected to diminish its fat content to 1.0–1.5 percent.

PASTURE STUDIES XXVII: THE EFFECTS OF MATURITY OF THE PLANT AND ITS LIGNIFICATION AND SUBSEQUENT DIGESTIBILITY BY ANIMALS AS INDICATED BY METHODS OF PLANT HISTOLOGY. W. J. Drapala, L. C. Raymond, and E. W. Crampton, *MacDonald College, Canada.*

In order to study the mode of deposition of lignin and the effect thereof of digestibility, techniques were developed to trace the process of lignification in red clover plants, to cut at five different stages of maturity. The degree of lignification was determined for each stage and the findings related to call digestibility as observed microscopically in the fecal residues. It was shown that lignification proceeds regularly with advancing maturity of the plant, and that regions around the vascular bundles are primarily involved in the process. In general, the increase in the number of undigested bits of tissue and their increase in particle size, is correlated with the increase in maturity of the plant eaten and its increase in lignification. It appears that only the lignified parts of the plant appear in quantity in the feces, excepting substances which are encased by a lignified cell wall.

THE MORE ACTIVE GOITROGENS AS FATTENING AGENTS FOR LIVESTOCK. Gayle W. Pipes and C. W. Turner, *Missouri Agricultural Experiment Station.*

It has been demonstrated that simple organic compounds which inhibit the normal function of the thyroid gland produce rapid and efficient fattening in poultry and some livestock. It should be of interest to know how quickly these compounds are absorbed into the blood stream and if a uniform level can be maintained during oral administration. It is essential to know if these drugs are present in the tissues in sufficient amounts to make the flesh unsafe for human consumption, and how long they are retained after the animal is returned to normal feed. In this study the chick was used as an experimental animal and the diurnal blood concentrations produced by three of the more active goitrogens, thiouracil, thiobarbital (5,5-diethyl-2-thio-barbituric acid) and 6-n-propyl thiouracil were investigated. Chemical determinations of these compounds in blood were made by the procedures of Christensen. At equal weight dosages these compounds produce similar levels in the blood. A short time after administration, these drugs reach maximum concentrations in the blood and then rapidly decline until little or none can be detected after twenty hours. Thiouracil concentrations in blood have been investigated under various feeding conditions, and it is evident that fairly uniform levels in the blood can be maintained only by feeding in the early morning hours. Biological assays indicate that the thiouracil or thiobarbital content of tissue is low (less than 5 mg. per 100 gm.) during the feeding period. On this basis the presence of these drugs in tissue does not present a serious problem since twenty pounds of tissue would contain only the average medicinal dose used in the treatment of hyperthyroidism.

THE APPARENT SYNTHESIS OF NICOTINIC ACID FROM TRYPTOPHANE BY THE HORSE. P. B. Pearson, B. S. Schweigert, and M. C. Wilkening. *Texas Agriculture Experiment Station.*

It has been shown that the horse maintained on a diet low in nicotinic acid excretes more nicotinic acid in the urine and in the feces than is ingested. Thus it is apparent that the horse is able by some mechanism to synthesize nicotinic acid. The possibility that tryptophane is a precursor of nicotinic acid has been investigated. Six grams of synthetic dl-tryptophane, which approximately doubled the intake of the natural isomer, were fed to each of three Shetland ponies. The amount of nicotinic acid, N-methyl-nicotinamide and tryptophane excreted in the urine was determined and compared with the amounts excreted when the basal diet was fed. When six grams of ditryptophane were fed there was an increase in the urinary excretion of nicotinic acid ranging from five to eight-fold over that on the basal diet. There was no consistent increase in the excretion of N-methylnicotinamide. The ingestion of added tryptophane resulted in an increase in the level of tryptophane in the blood and in the urine similar to that observed in the rat. The increase in nicotinic acid excretion after the ingestion of three grams of dl-tryptophane was significant, but correspondingly smaller than on the higher tryptophane intake. The data definitely indicate that the horse can utilize tryptophane as a precursor of nicotinic acid. The possibility that the reverse process may occur whereby nicotinic acid may serve as the precursor of tryptophane was also studied. In this case four grams of nicotinic acid were fed and the excretion of tryptophane was measured. The data afford no evidence that nicotinic acid may serve as a precursor of tryotpohane in the horse.

RESPONSE OF PIGS TO VARIOUS LEVELS OF RIBOFLAVIN. R. E. Van Poucke and J. L. Krider, *University of Illinois.*

Four groups of six pigs averaging 30 pounds were fed in drylot for 11 weeks on purified rations containing 0, 0.5, 0.75, and 1.50 milligrams of riboflavin per pound. The pigs fed the latter three diets were individually full-fed twice daily; the former pigs were full-fed as a group. All pigs were fed the riboflavin-free ration for 10 days preceding the test, and had been in dry lot since birth. The ration was composed of 61 percent corn starch, 25 percent Labco purified casein, 10 percent cerelose, 4 percent Hughes' salt mixture (JOUR. AN. SCI. 1: 320, 1942), and vitamins. Weekly each pig received 10 cc. of fortified cod-liver oil. The vitamin additions in milligrams per pound of ration were: thiamin 1.5, niacin 4.0, pantothenic acid 3.0, pyridoxine 2.0, choline chloride 475, and inositol 454. The average daily gains were 0.18, 0.61, 0.58 and 0.77 pound, with 4.50, 2.05, 2.26 and 1.92 pounds of feed required per pound of gain, respectively. For 100 pounds live weight per day, the pigs consumed 0, 1.30, 1.83 and 3.96 milligrams of riboflavin. The most thrifty group at the close of the test was the one receiving the highest level. These results indicate that riboflavin is associated with the utilization of feed for growth. Deficiency symptoms were noted in pigs of the basal group. Post-mortem showed extremely thickened skin; edematous areas beneath skin, edematous fluid infiltrated between the muscles, under muscular sheaths, and in the abdominal and thoracic cavities; enlarged spleen; anemia; and light gray discoloration of the kidneys.

PRELIMINARY STUDIES ON SUPPLEMENTING A RATION FOR BROOD SOWS WITH FOLIC ACID, VITAMINS, and VITAMIN CONCENTRATES. J. L. Krider, R. F. Van Poucke, D. E. Becker, and W. E. Carroll, *University of Illinois.*

Gilts produced by dams that had been fed continuously in drylot were used. The basal ration fed to the gilts from 100 pounds through gestation and lactation was composed of 72.5 percent of ground yellow corn, 25 percent expeller soybean meal, 0.5 percent fortified cod-liver oil, and 2 percent of a complex mineral mixture plus the following amounts of crystalline vitamins per pound of feed: 1.5 mg. thiamin; 1.5 mg. riboflavin; 5.0 mg. niacin; 6.0 mg. pantothenic acid; 2.5 pyridoxine; and 1.5 mg. choline chloride. The supplements fed with the percentage of pigs weaned and average weaning weight per pig in the six lots were as follows: (1) basal ration, 69 percent, 29.0 pounds; (2) basal ration plus 1.25 mg. pyracin,

136.0 mg. para-amino-benzoic acid, 454 mg. inositol, 0.2 biotin, 2.8 mg. alpha tocopherol, and 0.4 mg. of vitamin K per pound of diet, 32 percent, 24.4 pounds; (3) basal ration plus 10 percent dehydrated alfalfa meal, 97 percent, 32.4 pounds; (4) basal ration plus 1.5 percent AB liver extract, 82 percent, 34.3 pounds; (5) basal ration plus folic acid concentrate to supply .24 mg. of folic acid per pound of diet, 84 percent, 29.1 pounds; and (6) basal ration plus 5 percent Cerogras, 41 percent, 32.2 pounds. Gestation and lactation results were significantly improved by the addition of alfalfa meal or liver extract to the basal ration containing the known required B-vitamins, indicating that unknown required factors were being supplied by these products. Although the addition of the folic acid concentrate did not improve weaning weights significantly, the pigs from sows so fed were thriftier and more vigorous than were pigs from sows fed the basal ration.

VITAMINS A, C, AND NIACIN STUDIES ON THE BLOOD PLASMA OF PIGS. R. H. Grummer, P. H. Phillips, C. K. Whitehair, and G. Bohstedt, *University of Wisconsin.*

Blood samples of pigs were analyzed for vitamins A, C, and niacin before nursing, during the suckling period, and after weaning. The results showed that the plasma vitamins C and niacin were relatively high, and that the plasma vitamin A was low at birth. The vitamin C level at birth (.9 mgs. percent) increased approximately twofold by the time the pigs were 36 hours of age and decreased thereafter until a normal level of .8 mgs. percent was reached by the second week. A lower level of vitamin C appeared in the blood of the pigs following weaning. The plasma vitamin A at birth was .1 gamma/100 ml., reached a maximum level of .34 gamma/100 ml. in the week-old pig, decreased during the middle of the suckling period and rose again during the latter part of the suckling period. A lower level of vitamin A appeared in the blood of the pigs following weaning. The plasma niacin level decreased gradually from 8 gamma/100 ml. at birth to 5 gamma/100 ml. after weaning. Pigs suffering from "gray scours" were low in vitamin A and C, but normal in niacin.

DRIED PAUNCH CONTENTS AS A SUPPLEMENT TO TANKAGE AND SOYBEAN OILMEAL IN PIG RATIONS. E. F. Ferrin, *Minnesota Agricultural Experiment Station.*

Dried paunch contents from cattle were substituted for 8 percent of the ground yellow corn in rations for growing pigs when tankage or soybean oilmeal was the principal source of protein. Dried whey, alfalfa meal, irradiated yeast, niacin, riboflavin and iodized salt were included in all rations. Dicalcium phosphate and calcium carbonate were added to the rations containing soybean oilmeal to equalize the mineral intake. Pigs averaging 49 pounds in initial weight were fed in groups of 10 head on concrete floors. During the first 49 days of the feeding period, the average daily gain per pig was 1.47 lbs. in the lot receiving tankage and 1.46 lbs. in the lot receiving tankage plus dried paunch contents. The feeds consumed per hundredweight gain were 370 and 352 pounds, respectively. In two similar rations soybean oilmeal replaced tankage resulting in an average daily gain per pig of 1.04 pounds and with paunch contents added, 1.18 lbs. Feeds consumed per 100 lbs. of gain were 433 lbs. on the ration containing soybean oilmeal and 397 lbs. when dried paunch contents were added. The response of the pigs to the rations containing soybean oilmeal was so clearly abnormal that further investigations are being conducted with rats.

NUTRITIONAL SIGNIFICANCE OF FOLIC ACID, PARA-AMINOBENZOIC ACID AND ERYTHROCYTE MATURATION FACTOR FOR THE GROWING PIG. T. J. Cunha, L. K. Bustad, W. E. Ham, D. R. Cordy, E. C. McCulloch, D. H. Conner, I. F. Woods and M. A. McGregor, *State College of Washington.*

A purified basal ration containing 6 B-complex vitamins (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, and choline) was used. Eight lots of pigs were fed as follows: Lot I—Basal, Lot II—Basal+folic acid, Lot III—Basal+folic acid+erythrocyte maturation factor, Lot IV—Basal+PAB, Lot V—Basal+PAB+inositol+biotin, Lot VI—Basal +PAB+inositol+biotin+folic acid, Lot VII—Natural ration with 30 percent fish meal, and Lot VIII—Natural ration containing tankage as protein supplement with half the pigs

receiving folic acid. A modified paired-feeding technique was used so that all the pigs fed the purified rations were eating the same amount of feed. All the pigs were kept on raised floors to prevent coprophagy. After seven weeks on the above rations, very little difference in growth was obtained in the first six lots. Folic acid may have helped slightly with hemoglobin formation in Lot II. The pigs fed the ration with fish meal gained faster than those fed any of the purified rations. Sulfathalidine was added to the ration of the pigs fed the purified rations to determine the role of the vitamins when intestinal vitamin synthesis was inhibited. Data on gains, feed utilization, hemoglobin levels, red blood cells, white and differential white cell counts, coli and other micro-organisms in the feces, as well as the folic acid and biotin content of the feces and urine of pigs fed the natural and purified rations will be reported.

THE SUPPLEMENTARY FFFECT OF TRYPTOPHANE AND NICOTINIC ACID IN LOW PROTEIN RATIONS FOR WEANLING PIGS. R. W. Luecke, W. N. McMillen, F. Throp, and Carolyn Tull, *Michigan State College.*

A basal ration containing 14 percent protein made up of corn, 87; casein 5.5; soybean meal 5.5; mineral 2; and liberal amounts of thiamine, riboflavin, pantothenic acid and pyridoxine was fed to weanling pigs whose average weight was 27 pounds. Within 4 weeks symptoms of nicotinic acid deficiency appeared. Autopsy revealed thickening, congestion and yellowish caseated material on the mucus membrane of the colon. When the same ration was fed to another group and daily supplements of d,l-tryptophane fed to each animal good growth resulted. However, autopsy revealed lesions of a minor nature in the colon. The average daily gain for pigs in this group for the six week experimental period was 1 pound per pig. The feeding of tryptophane did not result in any increase in the urinary excretion of nicotinic acid, but a large increase in the excretion of N^1-methylnicotinamide was found. When the same basal ration was supplemented with liberal amounts of nicotinic acid and fed to a third group of weanling pigs the animals made slower gains than did the tryptophane supplemented group and lacked healthy appearance. The average daily gain of these animals over the same period was only 0.75 pounds. Autopsy revealed no abnormal pathology. Only 55 percent of the ingested nicotinic acid was excreted in the urine as nicotinic acid and N^1-methylnicotinamide. It appears that both nicotinic acid and tryptophane are needed in the ration used; however tryptophane is the more critical factor of the two.

EFFECT OF BREED, SEASON, AND AGE ON THE VARIATION OF VITAMIN A AND C BLOOD PLASMA LEVELS IN SHEEP. W. C. Weir, A. L. Pope, G. Bohstedt, and P. H. Phillips, *University of Wisconsin.*

In order to study factors which influence the variation in blood plasma vitamin A and C levels in sheep, four Hampshire, four Shropshire, and four Southdown ewes were selected from the University purebred flock and bled at monthly intervals for a two-year period. All ewes were fed and managed identically except during the fall breeding season, when the three breeds were alternated on different pastures. The data obtained in 1944–45 for vitamin A showed a slight but consistent breed difference. With the exception of one month, the Hampshire blood plasma vitamin A values were higher than those of the other breeds. In all breeds there was a tendency for the values for both vitamins A and C to be higher during the period when the ewes were in dry lot and during lactation. The vitamin A blood plasma values for the 1945–1946 season show a slight breed difference in favor of the Hampshires, but not as marked as the 1944–45 season. The average values for all three breeds are slightly lower than for the 1944–45 season. Higher values were again obtained during the time when the ewes were in dry lot and lactating. With respect to vitamin C blood plasma values, the slight breed difference of the previous season was not repeated. Higher levels were again obtained during the winter period when the ewes were in dry lot. Neither vitamin A or C blood variations showed any correlation with the age of the ewes during the 1945–46 season.

PROTEIN REQUIREMENTS OF LAMBS. F. B. Morrison, J. E. Briggs, E. W. Klosterman, J. I. Miller, E. J. Rousek, and J. P. Willman, *Cornell University.*

Experiments were conducted over six years to determine the amount of protein required by fattening western or native lambs, and to find whether urea could satisfactorily

replace a common protein supplement. Feed-lot trials with a total of 607 lambs were conducted by Messrs. Willman and Klosterman, and nitrogen-balance and indicidual feeding experiments with 144 lambs by Messrs. Miller, Briggs, and Rousek, all in consultation with senior author. Ration having 10.3 percent protein, air-dry basis, with nutritive ratios of 1:7 to 1:8, produced satisfactory gains and finish with lambs of 48 to 65 pounds initial weight. Higher protein levels did not increase gains significantly, and tended to produce slightly less finish. Less than 10 percent protein usually caused lower and more expensive gains. The effect of the lower planes of protein intake varied widely. In certain experiments lambs made as good gains on rations having only 9.0 percent protein as on higher levels, but in other experiments the low plane of intake is decidedly unsatisfactory. In one experiment lambs fed rations having 9.6 percent protein or less made very poor gains for more than 100 days. When changed to 11.0 percent protein, the gains became satisfactory. These differences in the results with various lots of animals emphasize the necessity of repeated studies, before safe conclusions can be drawn concerning protein requirements. In feed-lot trials urea was unsatisfactory as a substitute for linseed meal to balance shelled corn, corn silage, and small amount of hay.

THE COMPARATIVE VALUE OF A CAROTENE CONCENTRATE, ALFALFA MEAL, AND A FISH LIVER OIL IN MAINTAINING THE VITAMIN A CONTENT OF THE BLOOD AND LIVER OF FATTENING LAMBS. J. A. Hoefer and W. D. Gallup, *Oklahoma Agricultural Experiment Station.*

Two experiments were carried out in which a carotene concentrate (Research Carrot Oil), alfalfa meal, and a fish liver oil were fed to lambs at different levels of intake. Data were obtained on blood levels of vitamin A and liver storage. In the first comparison, between alfalfa meal and a carotene concentrate, the results indicate that the carotene of alfalfa meal is more available to lambs than the carotene from the carotene concentrate. In all cases, at the three levels tested, the lambs fed alfalfa meal maintained a higher average blood level of vitamin A and stored a greater amount in their livers, than the lambs receiving the carotene concentrate. Liver storage of vitamin A was quite variable although, in general, the lambs which received carotene in the form of alfalfa meal stored almost twice as much vitamin A in their livers as did the lambs which received an equivalent amount of carotene in the form of "Carrot Oil." In the second comparison, between alfalfa meal and a fish liver oil, the vitamin A per se proved to be far superior in maintaining liver storage, especially at the higher level of intake. At the lower level of feeding, 50 I.U. per kg. of body weight, the lambs receiving the fish liver oil maintained a liver storage of vitamin A approximately three times greater than that of the alfalfa meal lambs. However, when the rate of feeding was increased ten times, or 1500 I.U. per kg. of body weight, the difference in liver storage of vitamin A was approximately six times in favor of the lambs receiving the fish liver oil. Blood plasma vitamin A values are reported for 69 lambs, and liver storage values for 28 lambs.

Pasture and Range Section

M. L. Baker, *Chairman*

THE EFFECTS OF ROTATION GRAZING UPON BROMEGRASS-ALFALFA PASTURE YIELDS. M. A. Alexander and L. C. Newell, *University of Nebraksa.*

Two new pastures of the same size, one cross-fenced to make three equal areas, were used at the Nebraska Experiment Station, Lincoln, to determine the effects of rotation grazing with sheep upon the yield of bromegrass-alfalfa pastures from 1940 to 1943 inclusive. In 1940 rotation grazing furnished continuous grazing with the exception of four weeks. Non-rotation grazing failed seven weeks. In 1941, '42, and '43, rotation grazing produced continuous grazing for the pasture seasons; while non-rotation grazing failed six weeks in 1941, failed three weeks with very few pasture hours for two weeks in 1942, and failed four weeks with very few pasture hours for two weeks in 1943. The non-rotation grazed pasture was worn out and badly in need of renovation at the close of the 1943 grazing season. The rotation

grazed pasture was still good at the close of 1945. The tons of oven-dried bromegrass produced per acre for the rotation grazed pasture were .80, 1.85, 3.12, and 1.66; the tons of oven-dried alfalfa 1.40, 2.92, 1.53, and .69; and the tons of oven-dried weeds .03, 0, .05, and .05 respectively for the years 1940, '41, '42, and '43. For the same pasture seasons the non-rotation grazed pasture produced 1.49, 1.89, 3.24, and 1.62 tons oven-dried brome; 1.18, 1.36, .78, and .07 tons oven-dried alfalfa; and 0, 0, .72, and .82 ton of oven-dried weeds. Rotation grazing produced more pasture with practically no weeds and maintained the alfalfa stand.

PASTURE MANAGEMENT STUDIES OF A BROMEGRASS-ALFALFA MIXTURE. R. F. Fuelleman, W. L. Burlison, and W. G. Kammlade, *University of Illinois.*

A mixture of 12 pounds of smooth bromegrass and eight pounds of alfalfa per acre was seeded in September 1939. The field was divided into five plots. Four conditions of grazing were imposed, namely, heavy continuous, moderate continuous, moderate alternate, and heavy alternate. The fifth plot was used as a reserve. Grazing of yearling sheep was initiated in 1940 and continued through 1945. Alfalfa was eliminated from the moderate continuously grazed plot by 1942 and from the heavy continuously and moderate alternately grazed plots in 1943. An appreciable percentage of alfalfa remained on the heavy alternately pastured plot until the summer of 1944 when it was reduced to an occasional plant. Forage yields were high on all plots during the first four years. Animal gains over the six-year period ranged from high to low in the following order: heavy alternate grazing, heavy continuous, moderate alternate, and moderate continuous grazing. The conclusions reached were (1) on fertile soil, yields are large despite the method of management employed, (2) an alternate system of grazing provides the best utilization and gives alfalfa an opportunity to make new growth. Under moderate grazing conditions, alfalfa suffers from the aggressive competition of bromegrass, and (3) early season weeds, dandelion and peppergrass, are a factor under heavy continuous pasturing where vegetational cover is thin during the fall months.

THE LEVEL OF SOIL FERTILITY AND ITS RELATION TO PLANT AND ANIMAL PRODUCTION. R. J. Webb, J. M. Lewis, W. G. Kammlade, and R. F. Fuelleman, *University of Illinois.*

Six ten-acre fields at the Dixon Springs Experiment Station were pastured by grade ewes and lambs since 1942. The soil pH of two untreated fields was 4.2. A second pair of fields limed in 1936 received applications of super-phosphate in 1937, 1940, and 1941. The third pair of fields received limestone in 1936 and super-phosphate in 1937 and 1940. The last four fields varied in pH from 5.6 to 6.3 in the upper two inches of soil. The elemental phosphorous content on all six fields varied from 26 to 42 pounds per acre. Although no large difference in phosphorous content was found on the untreated compared with the treated fields, the relatively high acidity in the former may have made the phosphorous less available for plant use. Yields of desirable forage were larger in most seasons on the treated fields although total vegetation weights did not vary greatly in 1944 and 1945. Analyses of the forages for phosphorous and protein indicated that soil treatments favored an increase of these materials in the vegetation. No deficiency of calcium occurred, and differences in calcium content were due to the presence of legumes. Animal gains per acre for the four years of experimentation were 46, 109, and 127 pounds respectively for the untreated limed and phosphated fields. Small differences occurred in blood serum phosphorous of ewes from the three pairs of fields. There was not a significant difference in the average percentage of bone ash of lambs.

PASTURE FARMING SUITS MISSOURI. W. E. Etheridge, *University of Missouri.*

Missouri farming though highly diversified is broadly dominated by the production of livestock. Of the 255,000 Missouri farms, 88 percent are keeping and selling some form of livestock or its products. Missouri farmers are essentially livestock farmers because their native skills are mainly centered in animal production. These conditions of land and people, supplemented in recent years by new crops and the results of certain researches, are the basis

of a system of production which we call *pasture* farming. Despite the pressures of war, pasture farming has become widely established in Missouri. It is the foundation of our rapidly growing beef and dairy output. It is good for our land because it conserves, improves and efficiently uses the limited average upland fertility. It suits our farmers (1) because they understand it and possess the comparative skills necessary for its operation; (2) because it requires only a moderate use of machinery and manual labor; (3) because it can be conducted at low cost and with a low degree of risk; and (4) because it is withall profitable. We therefore conceive well-balanced pasture farming to be the essential general plan for Missouri agriculture for as long as agricultural economy and Missouri soil resources, shall exist near their present standards.

RELATIONSHIP OF CERTAIN FACTORS UPON THE GAINS OF STEERS ON PASTURE. G. O. Mott and S. R. Miles, *Purdue Agricultural Experiment Station.*

The relationship of several factors which influence the gains of steers with pasture as the sole ration has been studied during the past six years. Some of the factors under study are origin of steers, 2-year old compared with yearling steers, quality, fleshiness, and weights of the animals at the beginning of the grazing season. The main objective in these studies was to determine the factors which could be used more effectively to reduce the experimental error when using steers in grazing trials. Sorting steers for origin was very effective in reducing the experimental error. During two of the three years when both 2-year old steers and yearlings were used, the error was greatly reduced by sorting for this factor rather than distributing the animals completely at random. In the third year there was no advantage in sorting the 2-year old steers from the yearlings. Sorting for quality and condition had very little effect upon the experimental error in these trials because of the relatively narrow range of each of these factors in the animals studied. A study of the relationship of the weights of steers in the spring and the gains made during the grazing season, indicates that less than one percent of the variation in gains made by steers on pasture was accounted for by their initial weights.

BEEF PRODUCTION IN FLORIDA ON IMPROVED PASTURES. R. S. Glasscock, R. E. Blaser, J. E. Pace, and A. L. Shealy, *Florida Agricultural Experiment Station.*

Carpet grass without fertilization during a four-year grazing trials with yearling steers gave an average of 75 pounds gain per acre annually. Fertilized carpet grass yielded 148 pounds per acre. Carpet grass seeded with Lespedeza Striata produced an average of 219 pounds gain per acre annually as compared with 619 pounds for white clover and carpet grass. Blood studies during a three-year period on fertilized and unfertilized pastures, comparing common salt with a mineral mixture, containing sodium chloride, failed to give significant differences in hemoglobin regeneration, or in the phosphorus and calcium ratio in the blood plasma. The average individual weight gain for steers receiving the mineral mixture was 123 pounds for the grazing season as compared with 114 pounds for the steers receiving common salt. The average hemoglobin gain for the steers receiving mineral was 0.81 gms. per 100 cc. of blood. The steers receiving salt made an average gain of 1.41 gms. of hemoglobin per 100 cc. of blood. These figures are not significantly different. Steers that grazed unfertilized carpet grass pastures made an average daily gain of 0.45 pounds, while steers on fertilized carpet grass pastures gained 0.77 pounds. The pastures seeded with Lespedeza and white clover gave 0.96 and 0.93 pounds average daily gain, respectively. The phosphorus, potassium and calcium content of the carpet grass was increased because of fertilization. The introduction of leguminous plants increased the quality and quantity of herbage.

DETAILED MAPPING OF SELENIFEROUS VEGETATION ON SOILS OF PIERRE ORIGIN. W. V. Searight, A. L. Moxon, E. I. Whitehead, and F. G. Viets, Jr., *South Dakota Agricultural Experiment Station.*

Methods for mapping seleniferous vegetation are reviewed briefly. A combination of several methods was used to prepare a detailed map of three sections in Lyman County, South Dakota. The stratigraphic distribution of selenium sources in the Pierre bedrock was

mapped by determining the selenium content of western wheatgrass (*Agropyron smithii*) growing at different topographic positions. The selenium source beds are horizontal and the selenium content of the grass can be predicted (within four different ranges) for various elevations with the available data on selenium content of grass samples which have been collected from various locations on the ranch during the past 7 years. The four ranges of selenium content are: 0–5 p.p.m., 5–10 p.p.m., 10–20 p.p.m., and over 20 p.p.m. Five district horizons which support the growth of the indicator plant *Astragalus racemosus* Pursh have also been mapped. The topographical localization of highly seleniferous wheat grass to soils derived from certain horizons of the Mobridge member of the Pierre formation suggests the possibility of mapping of toxic areas on adjacent ranches largely on the basis of topography with enough selenium analyses of western wheatgrass to confirm the topographic position of the highly seleniferous source beds.

Sheep and Wool Section

J. E. Nordby, *Chairman*

THE CONSTRUCTION AND USE OF A SELECTION INDEX FOR RANGE RAMBOUILLET LAMBS. L. N. Hazel and Clair E. Terrill, *U. S. Department of Agriculture, Dubois, Idaho.*

A selection index was constructed for use in selecting range Rambouillet lambs at weanling age, the necessary statistics having been calculated from data on more than 2000 lambs. Standard partial regression coefficients, reflecting the relative economic importance of the various traits in the index, were as follows: face covering, 0.403; neck folds, 0.392; body weight, 0.379; condition, 0.155; staple length, 0.142; body type, 0.009. The index method was applied in selecting lambs in 1945, whereas in previous years lambs had been selected according to their general appearance. The initial sorting of the lambs into selected and cull groups was done with the index. Then minor changes were made when the index appeared to be in error. The ratio of the selection differentials for the lambs saved in 1945 to those saved in 1944 were as follows, for ram and ewe lambs, respectively: face covering, 1.14 and 1.80; staple length, 1.12 and 2.25; body weight, 1.19 and 2.44; body type, 1.02 and 1.69; condition, 0.81 and 2.75; neck folds, 0.77 and 0.50. These figures show that index selection was only slightly more efficient than selection by general appearance for ram lambs, where a small proportion of the lambs were selected, but was considerably more efficient for ewe lambs where a large proportion of the lambs were saved. Chief advantage of the index is that it emphasizes highly hereditary and economically important characters and provides a constant and objective basis for comparing individuals. Its disadvantages are that it is laborious to calculate and that some lambs must be culled for defects such as hairiness independently of the index.

HYBRIDIZATION OF WILD MOUFLON X DOMESTIC SHEEP. B. L. Warwick, R. O. Berry, and S. P. Davis, *Texas Agricultural Experiment Station.*

Mouflon sheep (*ovis musimon*) in common with all species of true sheep are fertile with domestic sheep. F_1 and three back-cross generations have been raised at the Texas Station. All F_1 progeny were white, hairy and intermediate tail-length. Normal mono-genic segregation of hairy to non-hairy occurred in the first back-cross ($F_1 \times$Rambouillet). Non-hairy segregates bred *inter se* gave only non-hairy progeny. Tail length segregated from the long length of the domestic type to the intermediate of the F_1. Color test matings of a modified black (brown) $\frac{3}{4}$ Mouflon ram$\times$recessive black domestic ewes resulted in some *white* offspring. This supplies critical evidence, in addition to the data from other sources, in favor of the hypothesis that the Wild Mouflon color is due to two recessive pairs of genes for black (plus modifiers) rather than one. Recessive black occurring in domestic flocks may result from either or both of these recessives. Selections of white, non-hairy, intermediate tailed back-cross individuals closely resemble the recurrent Rambouillet parent and are being bred

inter se looking toward the recovery of a commercially usable type of short-tailed fine-wool sheep.

SOME RESULTS OF EARLY VS. LATE LAMBING IN PRIVATE FLOCKS. Burl Winchester and A. B. Chapman, *University of Wisconsin.*

Seventeen purebred Shropshire rams were leased to 13 commercial lamb producers in August, 1943. Fourteen of these rams served in the same or another cooperator's flock for a second year. All ewes in the flocks were ear tagged and the lambs recorded and ears tagged at birth. A random sample of 8 lambs from each sire was brought to the University annually, and fed in individual sire progeny groups. Records were taken on details of type, body measurements, daily rate of gain, efficiency of feed utilization, market grade, dressing percentage, pelt weight, and carcass grade. The lambing season extended over a 15-week period from January 19 to May 23. The ewes which lambed about the middle of March produced the greatest weight of lamb per ewe at weaning time. This resulted from a higher percentage of lambs born and raised, and a higher final weight per lamb for the ewes which lambed in this period. Approximately 73 percent of the 1337 ewes in three breeding seasons conceived within three weeks after the rams were introduced. When the records were divided into early, middle, and late bred flocks, 22 percent of the ewes in the early bred group conceived during the first three weeks; 72 percent of the middle; and 90 percent of the late bred flocks conceived in that time. The percentage of the ewes which had conceived in each group remained about the same throughout the season after all had been with the rams for three weeks.

SINGLE WEIGHT VERSUS A THREE-DAY AVERAGE WEIGHT FOR SHEEP. H. W. Bean, *University of Illinois.*

The data used in this discussion are the individual experimental weights of sheep from thirty pens in five feeding projects at the Illinois Agricultural Experiment Station. The initial weights represent three consecutive daily weighings of 1335 sheep ranging from 45 to 95 pounds. The final weights, also taken on three consecutive days, are for 1301 sheep that completed the experiments. Comparisons are made between the total variation in the first day weights and in the average of the three daily weights for different groupings of the animals. The first grouping was made on the basis of experimental pens. The weights were then arranged according to different weight intervals. The deviation of the three-day average from the first day weight is also used as a standard of comparison. The purpose of making more than one weighing is to obtain a more reliable measure to represent the weight of the experimental animal. Statistical analysis of these data show that the three-day average weight does not consistently produce a smaller standard error than is obtained from the first day weighings. There appears to be no justification for continuing the practice of averaging three consecutive daily weights in order to obtain one measure to represent the initial or final weight of an experimental sheep.

THE NATURE OF GENETIC RESISTANCE OF SHEEP TO TRICHOSTRONGYLID WORMS. L. Otis Emik. *U. S. Department of Agriculture, Dubois, Idaho.*

The presence of a genetic resistance in sheep to trichostrongylid worms has been amply demonstrated. Eleven purebred lambs from the University of California flock were studied with the view of determining the nature of their resistance to the nematodes. The means of 20 days of counts of parasites' eggs in fecal samples from the lambs were used as a measure of infestation levels. Since egg counts follow a Poisson distribution, the mean square root of the egg counts is a more appropriate estimate of relative infestation. Significant differences were present between lambs. Experimental design was such that differences between means were largely due to inherent differences among individuals. The distribution of area of aggregate lymph nodes (Peyer's Patches) was measured in relation to intestinal area and several statistics were derived from the data. Mean egg count and mean square root of egg count gave significant correlation and regression coefficients when related to: a. the actual area of duodenum and jejenum devoid of lymph nodes, b. the statistical area, derived from regres-

sion of lymph node area on intestinal area, or c. the average area of intestine per unit area of lymph nodes. Immunologists have demonstrated that both cellular and humoral elements are instrumental in the individual's resistance response to intestinal nematodes. These elements are, at least in part, derived from the lymph nodes. While this study is not conclusive, the evidence points to a causal relation between lymph node distribution and genetic resistance of sheep to trichostrongylid worms.

KEMP AND OTHER MEDULLATED FIBERS IN THE FLEECES OF NAVAJO AND CROSSBRED LAMBS IN RELATION TO AGE. James O. Grandstaff and Harold W. Wolf, *United States Departments of Interior and Agriculture, Fort Wingate, New Mexico.*

The fleeces of 144 Navajo and 237 crossbred lambs born in 1940, 1941, 1943 and 1944 at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico, were sampled at 28-day intervals from birth to one year of age. Samples of 100 fibers taken from the middle of the left side and thigh of each lamb were analyzed microscopically for kemp and other medullated fibers. The 28-day samples from Navajo lambs contained an average of 6.8 percent kemp and 29.1 percent other medullated fibers, while at 364 days of age the percentages were only 0.9 and 8.4, respectively. The crossbred lambs did not differ significantly from the Navajo lambs at 28 days of age and followed the same general trend in fiber development, except that the decrease in medullated fibers was more rapid up to 84 days and more persistent in the later periods. Slightly more than 80 percent of the decrease in kemp for both breeds occurred between 28 and 84 days of age with a loss in other medullated fibers of 73 percent for the Navajo and 81 percent for the crossbred lambs. The changes in the percentages of kemp and other medullated fibers at the 13 ages were highly correlated. Differences between ages, years, and lambs within years were highly significant for both breeds. The differences between years were associated with a significant improvement in fleece quality of lambs produced between 1940 and 1944. Results of this study indicate that lambs which will have the most improved fleeces at yearling age can be selected with reasonable accuracy at about 112 days of age, when the fiber content of the fleece has reached a fairly constant level.

INHERITANCE OF COLOR ON THE LEGS IN COLUMBIA AND TARGHEE SHEEP. Clair E. Terrill, *United States Department of Agriculture, Dubois, Idaho.*

The inheritance of brown or black color on the legs was studied on 1517 Columbia and 1051 Targhee weanling lambs born from 1941 to 1945 and their dams. The degree of color on the legs was scored from 1 to 5. Lambs having no color were scored as 1 and those with almost completely colored legs were scored as 5. Twelve percent of Columbia lambs and 15 percent of Targhee lambs had leg color. The percent of dams with color was higher in each breed. This indicates that little selection against color has been practiced in ewes, but that some progress has been made in eliminating color through selection of the sires. Leg color appears to be recessive because many lambs with color are from parents without color. However, when both parents had color less than half of the offspring had color, indicating that more than one pair of genes are involved. Heritability of leg color was estimated from intra-sire regressions of offspring on dam and from half-sib correlations. The latter gave lower estimates probably because the sires had been selected for absence of color. Estimates of heritability from intra-sire regressions of offspring on dam were $0.26 \pm .05$ and $0.32 \pm .07$ for Columbias and Targhees respectively. These estimates are consistent with progress which has been made from selection. Further progress toward eliminating leg color will be slow because its incidence is already low. Culling of all sheep with color would reduce the percent of lambs with color to about 8 in Columbias and 12 in Targhees.

THE RELATIONSHIP OF CERTAIN CONSTITUENTS OF THE MILK AND BLOOD PLASMA OF EWES TO THE BLOOD PLASMA OF THEIR LAMBS. A. L. Pope, P. H. Phillips and G. Bohstedt, *University of Wisconsin.*

Since most production records reveal a high mortality of infant lambs, this study was

undertaken to determine the vitamin A and C status of lambs in relation to that of their dams. Periodic blood analyses for vitamins A and C were made on young lambs beginning at birth before they had received colostrum. The ewe's blood was also analyzed at these periods. During the experiment, liver and milk analyses were also made. The analyses showed lambs were deficient in both vitamins A and C at birth when compared with their dams. The plasma vitamin levels of the lambs reached an apparently normal range of 20 to 30 gamma percent after the ingestion of colostrum. However, during the first year of life the lambs' plasma vitamin A levels were not so high as those for mature sheep. Liver analyses confirmed the plasma determinations. The colostrum contained six to seven times as much vitamin A as later milk. Thus the rapid increase in the lambs' plasma following birth was due to the vitamin A potency of the colostrum. A different picture was found with respect to vitamin C. While this vitamin was also low in the plasma of the newborn lambs, the values continued to decrease until about four days of age, after which they increased to a normal range. The colostrum was no higher than the normal milk. Therefore, these lambs were deficient in plasma vitamin C during the first four days of life, and the colostrum did not increase these blood values to a "safe" range as in the case of vitamin A.

THE EFFECT OF COBALT ON GROWTH AND CERTAIN BLOOD CONSTITUENTS OF SHEEP. A. L. Pope, G. Bohstedt, and P. H. Phillips, *University of Wisconsin.*

Two groups of sheep from a cobalt-deficient area of northeastern Wisconsin were fed hay grown in that region, plus corn and corn gluten meal. One group was fed 1 ounce of cobalt sulphate ($CoSO_4 \cdot 7H_2O$) per 100 pounds of granulated salt, while the other group was fed granulated salt alone. Both salts were fed ad libitum. The sheep that received the cobaltized salt were normal, healthy sheep throughout the experiment. After three months the sheep receiving salt alone developed typical symptoms of cobalt deficiency. They had a markedly decreased appetite, and blood analyses showed them to be critically low in hemoglobin, vitamin A, and vitamin C. One ounce of cobalt sulphate ($CoSO_4 \cdot 7H_2O$) per 100 pounds of salt fed these cobalt-deficient sheep quickly alleviated these symptoms. The most noticeable effect of supplementing their ration with cobalt was the resumption of a normal appetite within one week. This increased feed intake was reflected by a sharp increase in growth and blood plasma vitamins A and C concentration. The return to a normal hemoglobin level followed the cobalt therapy, but was not so rapid as the appetite and growth responses.

OBSERVATIONS ON THE EFFECT OF VITAMIN A ON REPRODUCTION OF SHEEP FED LOW QUALITY ROUGHAGES. T. J. Cunha, E. J. Warwick, and R. J. Evans, *State College of Washington.*

Four lots of seven-year-old ewes were fed the following rations: Lot I—alfalfa hay, Lot II—wheat hay, Lot III—smooth bromegrass straw, and Lot IV—big bluegrass straw. Half of the ewes in each lot were given 100,000 I.U. of vitamin A weekly. In each lot, the ewes had access to all the roughage they could consume. The amount of grain and protein supplement fed was regulated so that the ewes in all lots were obtaining approximately the same amount of protein and total digestible nutrients. Salt and bone meal were fed ad lib. For three months prior to being placed on experiment, the ewes were grazed on green mountain feed. There was very little difference in reproduction by the ewes fed the four different roughages, regardless of whether vitamin A was fed or not. The comparable results obtained with all roughages were most likely influenced by the fact that the ewes had grazed on green mountain feed during the summer and had stored enough vitamin A to carry them through reproduction even on a low carotene roughage such as wheat hay. Blood plasma vitamin A determinations of the ewes and lambs showed very little difference, regardless of roughage fed or whether vitamin A was given or not. The ewes ate only about half as much of the two grass straws as they did of the wheat hay or alfalfa. This stresses the importance of supplemental feeding of ewes fed low quality, unpalatable roughages or forages.

THE INFLUENCE OF THIOURACIL AND THIOUREA ON THE GROWTH AND FATTENING OF LAMBS. F. N. Andrews, W. M. Beeson, E. R. Barrick and Claude Harper, *Purdue Agricultural Experiment Station.*

Eight lots of 20 lambs each were used. The lambs were predominantly of Rambouille breeding, averaged 74 pounds in weight at the beginning of the study, and were fed for a period of 84 days. All lots received a basal ration of No. 2 shelled yellow corn, well matured corn silage, red clover hay and a pelleted protein concentrate made up of equal parts of expeller process soybean oil meal, alfalfa meal and two per cent salt. Thiouracil and thiourea were incorporated in the pellets at various levels. Thiouracil intakes of 0.175 gm. to 0.544 gm. per lamb daily had no significant effect on the rate of gain but thiourea significantly reduced the rate of gain when fed at levels from 0.048 to 0.071 gm. per lamb per day. Feed intake was somewhat reduced in all lots receiving thiouracil and thiourea, presumably because of their objectionable taste. When more than 0.333 gm. of thiouracil daily was fed the feed requirements per pound of gain increased. Thirty-five percent of the carcasses of the control lambs received the top market grade in contrast with 55 and 60 percent in the lots receiving 0.175 and 0.333 gm. of thiouracil per lamb daily respectively. Carcass quality was lowered by the addition of thiourea to the ration.

PHYSIOLOGICAL EFFECTS OF THIOURACIL ON SHEEP. E. R. Barrick, W. M. Beeson, and F. N. Andrews, *Purdue Agricultural Experiment Station.*

Four lots of sheep containing six Texas yearlings each were used to study the physiological effects of thiouracil administered by capsule at the rate of ½ gm., 1 gm., and 3 gm. per sheep daily. Blood plasma cholesterol, blood sugar, hemoglobin, red and white blood cell counts were determined every two weeks for a ten week period while animals were in dry lot receiving a ration of shelled yellow corn and red clover hay. Corn consumption was greatly decreased in lots receiving 1 gm. and 3 gm. of thiouracil. Blood plasma vitamin A, carotene, total protein, albumin, globulin and ascorbic acid were determined during the latter part of the dry lot period and for a ten day period on pasture. Blood cholesterol values of the sheep receiving 1 gm. and 3 gm. of thiouracil daily increased approximately 30 percent over pretreatment values and averaged about 40 percent higher than the controls. Cholesterol values for the lot receiving ½ gm. of thiouracil did not increase above the controls. Vitamin A values were lower in the treated lots than in the controls and this difference became more pronounced when the carotene intake was increased by turning the animals on pasture. Carotene values were found to be higher in the treated animals and the differences became greater with increase in carotene intake. Although not pronounced there tended to be an increase in the total protein and decrease in albumin in the blood plasma of the treated animals. The globulin was significantly higher in those treated than in the controls. Blood sugar, hemoglobin, and red and white cell counts were not affected by thiouracil treatment. Ascorbic acid values did not appear to be affected by the treatment.

A STATISTICAL STUDY OF DATA ON APPARENT DIGESTIBILITY OF HAYS BY SHEEP. Burch H. Schneider, Helen M. Pavlech, and Henry L. Lucas, *West Virginia University and North Carolina State College.*

The data from 868 digestion trials published by 183 authors on 28 kinds or species of hays fed to sheep were analyzed statistically. On each hay there were data from 10 to 123 individual trials conducted by 2 to 20 investigators. Analyses of variance showed significant differences among the hays in both chemical composition and digestibility of the nutrients. Also, the composition and digestibility figures reported for each hay varied significantly among investigators. Multiple regression studies showed that significant relationships existed between the proximate chemical composition and digestibilities of the proximate nutrients. Covariance adjustments of the digestion coefficients for composition did not remove the significant differences which existed among the hays or among investigators on the same hay. When the proximate composition of any sample of hay is known, the digestibilities of the

nutrients may be predicted. These predictions will be more accurate than any fixed average digestion coefficients. A different prediction equation should be used for each kind of hay. Specific equations for each hay may be written as follows: (1) $K = C_K + 1.56\,J_0 - 0.07\,N_0 + 1.51\,P_0$; (2) $R = C_R + 0.74\,J_0 + 0.36\,N_0 + 0.72\,P_0$. K and R are the predicted values and C_K and C_R the constants for the digestion coefficient of crude protein and the T.D.N., respectively. J_0, N_0, and P_0 represent the observed (or determined) percentages of protein, N-F.E. and fat, respectively, of any sample. The constants to be substituted for C_K and C_R in the formulas for hays are: Alfalfa 45, 28: Red Clover 34, 29; Orchardgrass 36, 29; Soybean 36, 25; Sudangrass 34, 28; and Timothy 33, 31, respectively.

PHYSICAL BALANCE AS A FACTOR IN DETERMINING THE EFFICIENCY OF FEED UTILIZATION BY FATTENING LAMBS. Rufus F. Cox, *Kansas Agricultural Experiment Station.*

Seven experiments were conducted in each of which three lots of lambs were fed rations consisting of 35 percent concentrates to 65 percent roughage, 45 percent concentrates to 55 percent roughage, and 55 percent concentrates to 45 percent roughage, respectively. Two additional experiments followed in which bleached poplar sulphite and Biron groundwood screenings constituted the only roughage. These were fed at levels resulting in crude fiber-total digestible nutrient ratios of 1 to 3.208; 1 to 3.815; and 1 to 4.539, respectively, corresponding in physical balance to the three proportions of concentrates to roughage used in the first seven experiments. The lambs were not restricted in amount of feed but only in proportion of concentrate to roughage. Slaughter and carcass studies, microbial counts and pH determinations of the rumen ingesta and of feces, digestion trials, water consumption records, and the effects of supplemental feeding of vitamin A and glucose were other features of these investigations. The rate of gain in seven of the nine experiments, and the efficiency of feed utilization as measured by gains per 100 pounds of total digestible nutrients consumed were highest for lot 2, receiving 45 percent concentrates to 55 percent roughage. It is concluded that an optimum proportion of concentrates to roughage exists; that as bulky rations are increased in concentration the gains made and the efficiency of feed utilization increase up to a certain level; as the concentration is further increased, the gains and the efficiency of feed utilization turn downward. A second fact is that weight gains and efficiency of feed utilization by lambs are not always positively correlated with either the dry matter or the total digestible nutrient intake, but appear to follow a certain balance between these two factors.

SOME EFFECTS OF ADMINISTERING COPPER SULPHATE, COPPER-NICOTINE, AND PHENOTHIAZINE WITH AND WITHOUT COBALT SUPPLEMENT. Burl Winchester and C. A. Herrick, *University of Wisconsin.*

Conditions and experiences on two Shawano County Farms were quite similar. Farm I lost about 350 lambs from 750 ewes before July 1, 1943. Farm II lost 84 percent of the lambs from 124 ewes. Veterinarians found a syndrome and no primary cause. Blood analysis and fecal egg counts revealed very low hemoglobin and clinical parasitism. It was decided to study the parasitism in relation to a mineral deficiency with which it seemed associated. In September 1943 a standard ration was recommended for both farms and cobalt chloride was supplied to Farm II and fed in salt. On June 16, 1944 all ewes and lambs on both farms were marked, weighed and randomized into four treatment groups and given copper sulphate, copper nicotine, and phenothiazine drenches, and no treatment respectively each month until September 23 when they were graded and weighed. Identical treatments affected sheep in the two flocks quite diversely. One hundred sixty-three of the 543 lambs in Flock I died. Three percent died in Flock II which had cobalt. Lamb losses were about the same in all four groups on Farm II but on Farm I were 44 percent among the copper sulphate group and about 23 percent in the phenothiazine and control groups. In Flock I no drench was of value. In Flock II (fed cobalt) lambs in all treatment groups were superior to those in Flock I and to the control group in body weight, market grade and daily rate of gain.

Swine Section

H. G. Zavoral, *Chairman*

SOME OBSERVATIONS ON THE FERTILITY OF BOARS REARED IN A RESTRICTED ENVIRONMENT. L. E. Hanson, *Nebraska Agricultural Experiment Station.*

Seven Duroc Jersey boars from two litters were reared on concrete floors with very little room for exercise. They were farrowed by sows which had been raised under similarly restricted conditions from a weight of 75 pounds. The boars grew well on a diet of natural feedstuffs, fortified with irradiated yeast. They began to exhibit sex interest at about 5 months of age, and were used for breeding at 8½ to 9 months of age. Thirty-one gilts and one tried sow were bred. After the breeding season the boars were castrated and the spermatic fluid of the testicles of each of the boars showed that spermatozoa were present in "normal" numbers and they were of normal morphology and motility. A report will be made on the litters from these matings.

EQUIPMENT FOR RAISING BABY PIGS UNDER LABORATORY CONDITIONS. W. W. Green, H. H. Brugman, and L. M. Winters, *Minnesota Agricultural Experiment Station.*

The raising of baby pigs under laboratory conditions should have many advantages but special equipment is necessary. Cages which were found practical to hold 10 baby pigs were 24″ high, 36″ wide and had 32 square feet of floor space. Permanent floors were made of ½″ hardware cloth. Inset floor panels of ¼″ hardware cloth were used for very young pigs. The sides were made of 1″ hexagonal poultry mesh stapled to a wooden framework. Milk was fed *ad lib* by use of a removable trough and a vacuum type reserve can. A series of 6″×6″×6″ stalls over the trough prevented crowding when the pigs drank. New milk was given once a day. Cages were cleaned by use of hot water under pressure and feeding equipment was cleaned and sterilized with tri-sodium phosphate, boiling water and steam.

The baby pigs (0–8 weeks of age) did not appear to suffer when raised on wire. No knee nor hock sores developed from lying on the wire and pasterns were not weakened. Although confined to a small space, the pigs did not seem to suffer from lack of exercise. From a sanitary standpoint, it would be best to have the cages and stalls constructed entirely of metal.

EFFECT OF VITAMIN SUPPLEMENTATION AND SULFA DRUG THERAPY ON "GRAY SCOURS" IN SMALL PIGS. C. K. Whitehair, R. H. Grummer, G. Bohstedt, and P. H. Phillips, *University of Wisconsin.*

A digestive disturbance in small pigs characterized by "gray scours" is prevalent in many Wisconsin swine herds. Symptoms of the syndrome are diarrhea, dermatitis, anorexia, alopecia, and poor growth. These symptoms resemble those described for certain vitamin deficiencies, particularly niacin, pantothenic acid, and biotin. Vitamins A, C, E, niacin, pantothenic acid, biotin, and riboflavin were fed individually and in various combinations to the pigs prior to, and during the digestive disturbances. Pantothenic acid (2 mg. per pig per day) was the only vitamin supplement that noticeably improved the condition of the pigs. Vitamin C (10 mg. per pig per day) and vitamin A 2500 I.U. per pig per day) did not increase the blood level of these two vitamins. Sulfathiazole was partially effective in controlling the disorder, but only while the pigs were being treated.

THE INFLUENCE OF THE BOAR ON LITTER SIZE. A. L. Musson, *Iowa State College.*

A study of 341 litters from four purebred Poland China and Danish Landrace inbred lines at the Iowa Experiment Station showed that in these data the boar has little or no influence on the size of his litters. This study was stimulated from a semi-controlled farm source which indicated that the boar does influence litter size. The case of particular interest was observed on a farm where two unrelated Poland China boars were mated to groups of sows of similar age and breeding. One boar sired seven litters averaging 11.6 pigs per litter. The other boar sired eight litters with an average of 6.2 pigs per litter. The difference is of such magnitude

as would happen only once in a hundred or more times by chance alone. The implication is that a threshold of some width exists between complete fertility and sterility, but this requires further investigation.

NUTRITIONAL ADEQUACY OF CULL PEAS AS A PROTEIN SUPPLEMENT FOR GROWTH, REPRODUCTION, AND LACTATION OF SWINE. T. J. Cunha, E. J. Warwick, and M. E. Ensminger, *State College of Washington.*

Four years' work has shown that cull peas are an excellent protein supplement for growing-fattening pigs on pasture. In last year's dry-lot work, the pigs fed cull peas as the only protein supplement gained as fast as pigs fed tankage, and faster than those fed soybean oil meal (5 percent alfalfa in all rations). With 15 percent alfalfa in the ration, the pigs fed cull peas gained faster than the pigs fed either tankage or soybean oil meal. In all cases, the cheapest gains were made by the pigs fed cull peas. In this year's dry-lot trials, the pigs fed tankage gained less daily than the pigs fed cull peas (both groups were fed 5 percent alfalfa in the ration). The pigs fed tankage required 75 pounds more feed per 100 pounds of gain than those fed cull peas. Half of the pigs fed tankage developed an exudate over the surface of the body which cleared up when the pigs were turned out to pasture at termination of the experiment. This exudate did not occur with the pigs fed cull peas. Pigs fed cull peas during growth are now being carried through reproduction. Three-fourths of the gilts fed 5 percent alfalfa during growth have not conceived after 3 months of being kept with the boar, whereas those fed 15 percent alfalfa during growth all conceived and are due to farrow soon. A complete report on reproduction and lactation data will also be given.

THE EFFECT OF THIOURACIL ON EFFICIENCY OF GAINS AND CARCASS QUALITY IN FATTENING SWINE. W. N. McMillen, E. P. Reineke and L. J. Bratzler, *Michigan Agricultural Experiment Station.*

The effect of thiouracil fed as .1 percent of the ration on economy of gains and carcass quality was studied with Chester White and Yorkshire market pigs. Compared with the controls, five Chester White barrows averaging 162 pounds and fed ad libitum on a ration containing thiouracil for 41 days made .16 pound less daily gain, but required 14 percent less feed per unit of gain. Five Yorkshire pigs given thiouracil for the same period averaged .09 pound less daily gain and required 19 percent less feed per unit of gain. Pigs of both breeds in the experimental groups became lazy toward the end of the second week and became increasingly sluggish as the trial progressed. The greater increase in the economy of gain in the Yorkshires as compared to the Chester Whites is believed to be due to a higher natural thyroid secretion rate in the former and consequently a greater reduction in rate of metabolism under the influence of thiouracil. Except for a tendency toward more lean in the ham facing of the experimental groups, there were no significant differences in the carcasses attributable to the thiouracil treatment.

RYE PASTURE, FISH SOLUBLES AND ALFALFA MEAL COMPARED IN BROOD SOW RATIONS. J. L. Krider, D. E. Becker, and W. E. Carroll, *University of Illinois.*

Previously it had been demonstrated that a basal ration composed of 67 percent ground yellow corn, 25 percent expeller soybean meal, 5 percent dehydrated alfalfa meal, 2.5 percent complex mineral mixture, and 0.5 percent fortified cod-liver oil was inadequate for gilts fed in drylot during gestation and lactation. The gilts used in the current experiment had been on pasture previously, and were started on test before they were bred. The supplements fed during gestation and lactation with the average weaning weight per pig and the percentage of pigs weaned were, respectively, as follows for the lots: (1a) basal ration plus fall-seeded rye pasture, 30.4 pounds, 79 percent; (1b) basal ration plus rye pasture during gestation basal ration only in drylot during lactation, 28.2 pounds, 87 percent; (2) basal ration 98 percent plus 2 percent sardine condensed fish solubles in dry lot, 30.0 pounds, 91 percent; (3) basal ration 98 percent plus 2 percent menhaden condensed fish solubles in dry lot, 26.4 pounds, 92 percent; (4) basal ration 96 percent plus 4 percent sardine condensed fish solubles in dry-lot, 29.2 pounds, 74 percent; and (5) basal ration plus 10 percent dehydrated alfalfa meal fed in

drylot, 25.0 pounds, 76 percent. The deficiency (or deficiencies) of the basal ration were corrected by supplementing it with rye pasture, 10 percent alfalfa meal, and either 2 or 4 percent of condensed fish solubles (fresh basis). The menhaden solubles were almost as effective as the sardine product in supplementing the basal ration. When the basal ration was fed in drylot during lactation, the residual effect of rye pasture feeding during gestation was manifested.

ABNORMAL BLEEDING IN FARM LIVESTOCK. M. E. Muhrer, R. F. Gentry, and A. G. Hogan, *University of Missouri.*

Losses from hemorrhage following dehorning of cattle receiving a ration of moldly mill feed, sorgo silage, and moldy lespedeza hay (reportedly free of sweet clover) were observed. The hemorrhagic animals were found to have a long prothrombin time. The lespedeza hay was the only ingredient which would produce this condition when fed to experimental rabbits. The rabbits refused to eat a sufficient quantity of the moldy hay to produce a severe bleeding condition unless it was mixed with "Cerelose" (corn sugar). The hemorrhagic condition in the rabbits, as in the cattle, was due to a prothrombin deficiency. The rabbits lost considerable weight when fed the moldy lespedeza hay. They consumed only a small amount of the hay, but the hemorrhagic tendency was not due to starvation since animals on alfalfa at the same low level of intake retained their normal prothrombin time. Fatal hemorrhages were observed following castration of swine that could not be traced to a nutritional factor. All of the affected animals were from the same line of breeding. This hemophilia-like disease in swine was found to be inherited as a recessive characteristic. The prothrombin time was normal but the coagulation time of whole blood and plasma was abnormally long and presumably the blood was deficient in an available source of thromboplastin. A colony of these bleeder animals is being maintained and investigation of the abnormality is now in progress.

SOME VITAMIN REQUIREMENTS OF THE PIG AS RELATED TO REPRODUCTION AND LACTATION. M. E. Ensminger, J. P. Bowland and T. J. Cunha, *State College of Washington.*

The effects of a deficiency of either thiamine, riboflavin, or choline on reproduction and lactation in swine were studied over a two-year period. Eighteen gilts were used, fourteen of which farrowed. The purified control ration consisted of sugar, casein, lard and minerals supplemented by vitamins A, D, E, K and the B-complex vitamins, niacin, pantothenic acid, pyridoxine, thiamine, riboflavin, and choline. The latter three vitamins were deleted individually to create thiamine, riboflavin or choline deficient rations. A modification of the paired-feeding technique was used. Although limited numbers were used, it would appear that the control ration is deficient in some unknown factor. Two sows on the control ration for only 52 days prior to gestation farrowed and weaned normal litters; whereas, a third sow on this same ration 140 days prior to parturition, farrowed 10 pigs of which only one survived. The thiamine deficient sows produced pigs with many leg abnormalities, and high mortality at birth. The pigs which survived had an unthrifty appearance and low weaning weight. A deficiency of riboflavin resulted in loss of appetite, parturition greatly ahead of normal or absorption of the fetus. All pigs living at birth died within 48 hours after farrowing and showed post mortem abnormalities. The lack of choline lowered the pregnancy gains of the sows slightly, and many of the pigs farrowed were weak, had spraddled legs, and showed muscular incoordination. There was also heavy mortality in the latter group.

THE EFFECT OF SYNTHETIC THYROPROTEIN ON LACTATION AND GROWTH IN SWINE. E. P. Reineke and W. N. McMillen. *Michigan Agricultural Experiment Station.*

In preliminary investigations to determine the approximate dosage of synthetic thyroprotein required for physiological stimulation in swine, a "Protamone" preparation containing 3.16 percent thyroxine by chemical analysis was given to market hogs of the Chester White breed at levels comprising 0.005 percent and 0.01 percent of the ration. At the lower dosage level no noticeable signs of hyperthyroidism were observed after 12 days of treatment. At the

higher level some loss in body weight, accompanied by symptoms of nervousness, occurred. Thyroprotein was given as 0.005 percent of the ration to two sows that were deficient in milk production, as indicated by extreme thinness and emaciation of their pigs. Lactation improved markedly as judged by improvement in the pigs and by the external appearance of the sows' udders. The rate of growth and development of 8 Berkshire pigs receiving 0.005 percent to 0.0075 percent of thyroprotein in their grain ration beginning at an average weight of 42 pounds per pig was compared with that of 8 litter mate controls. The treated group gained slightly more than the controls beginning with the second week of treatment. The feed required per unit of gain was slightly less. After 8 weeks of treatment the experimental group appeared more mature, thicker and meatier, and considerably more uniform than the controls. The influence of thyroprotein feeding on carcass quality is being studied. Results of investigations on the tolerance of swine to higher levels of thyroprotein will also be presented.

PLACENTAL AND MAMMARY TRANSFER OF VITAMIN A IN SWINE. J. Wm. Thomas, J. K. Loosli, and J. P. Willman, *Cornell University.*

A study was made in the spring of 1946 of the placental and mammary transfer of vitamin A which involved 15 sows and their pigs. One group of sows was fed the regular herd ration, a second group was given the same ration plus a daily supplement of 400,000 I.U. of vitamin A and one sow was given 400,000 I.U. of carotene. The supplements were fed for about a month before the sows were due to farrow. Newborn pigs were killed before they suckled to determine the vitamin A content of the liver and blood plasma. The livers from pigs produced by sows fed the herd ration contained 4.7 micrograms of vitamin A per gram of liver; those from sows fed supplemental vitamin A contained 35.8 micrograms, and when carotene was fed 7.9 micrograms. The total vitamin A content per liver averaged 345, 4,615 and 593 I.U. for the three diets respectively. The level of vitamin A in the blood plasma of pigs killed at birth from sows on the herd ration averaged 6.4 micrograms per 100 ml. Pigs from sows fed a vitamin A supplement had a value of 8.4, and pigs from the sows fed carotene had a value of 6.5 micrograms of vitamin A per 100 ml. of blood plasma. A vitamin A concentration of 169 micrograms per 100 ml. was found in colostrum obtained during parturition from sows on herd ration. There were 519 micrograms of vitamin A per 100 ml. of colostrum from sows fed vitamin A as compared with 124 micrograms for the sow fed carotene. These data show that the addition of vitamin A to the prepartum diet of the pregnant sow increased the vitamin A content of the livers and plasma of the newborn pigs and raised the concentration of vitamin A in the colostrum.

Teaching Section

R. F. Cox, *Chairman*

THE USE OF SLIDES IN TEACHING HORSE PRODUCTION TO ILLUSTRATE MARKET AND SHOW CLASS. Byron H. Good, *Michigan State College.*

The use of slides merely touches the surface thinking in terms of ultimate possibilities in visual education. Their convenience makes them ideal to illustrate and supplement class room discussion, especially when real specimens are an impossibility We have arranged a group of slides which are used as an introduction to the course in horse production. These slides present a panorama view of the market and show classes of horses. Each slide is a picture of a horse which represents some particular market or show classification. In selecting individuals to make these slides we have kept the ideal in mind and also an animal with an interesting record which is an effort to secure retention in our teaching. Along this phase of the work I like to show some tack used exclusively by the class of horses we have on the slide. An example of one of the slides we use in the work horse division is a replica of the famous Belgian mare Pervenche. This mare was a study of correctness thinking in terms of draft type and Belgian type. She was a mare with a great show record and brood mare record. Other slides showing interesting drafters are included to illustrate the draft breeds. In the light horse section we have slides representing heavy harness, light harness, saddle and pony

divisions. Some of these slides represent outstanding show horses of the respective divisions.

AUDIO-VISUAL AIDS IN TEACHING THE FIRST COURSE IN ANIMAL HUSBANDRY. William L. Henning, *Pennsylvania State College.*

The problem of presenting the first general course in Animal Husbandry to students varying in numbers from 25 to 250 or more is quite different from teaching advanced courses with a small number of students. We no doubt will nearly all agree that ideal teaching methods may be developed in small classes of less than twelve students or that ideal methods may be used, for example in training a judging team of six or eight students. This becomes a private tutor course with detailed individual instruction where nothing can be superior to work with live animals or carcass study as for example, instruction in meats. However, it is a physical problem and economic fact that many first course students are taught in sections from less than 25 up to 250 students at a time. Ideal classroom instruction should be given to students of 25 or less in a section. If the so-called lecture period is given to large numbers, then the laboratory classes should be reduced to no more than 25 students or the laboratory exercises merely become a demonstration. Visual aids may be used in teaching large sections of Animal Husbandry students. 2″×2″ Kodachrome slides are very useful. Sixteen millimeter movie films in black and white and color as well as sound movies are most valuable. Where live animals may not be available, then visual aids are next best. From 30 to 50 percent of the time used for classroom work may profitably be used for this purpose, depending upon the course content or its object.

VISUAL AIDS IN TEACHING ANIMAL NUTRITION. T. S. Sutton, *Ohio State University.*

It is usually difficult, if not impossible, to have at hand suitable demonstration material for use in the classroom. One must, therefore, depend upon prepared specimens and photographic records in order to effectively present the subject. Three types of visual aids which are used at The Ohio State University to vitalize the subject of nutrition will be demonstrated.

A VISUAL AID IN TEACHING PEDIGREE ANALYSIS AND SIRE SELECTION. S. W. Mead, *University of California.*

Visual equipment designed to aid in the teaching of pedigree analysis and sire selection has been used successfully. The equipment consists of a plywood background 57×52 inches on which are painted, in black, the conventional pedigree lines of a four-generation pedigree. Above each line is a slot in which are placed cards. Printed on each card is the name of animal it represents, with other information desired, such as records of production and show-ring winnings. The pedigrees of several real or fictitious animals may thus be studied and analyzed from an appropriate number of cards. The cards are removed, by the instructor, in succession according to a prearranged order. A variety of information may be printed on the cards in order that students may be taught to differentiate between important and unimportant information commonly found in pedigrees of sales animals. By proper arrangement of data one may also demonstrate the use of conversion factors in comparing production records made at different ages and under various conditions. Instruction in pedigree analysis as previously given has required a number of pedigree charts, together with other material. The method described concentrates the equipment into one piece, and the removal of the cards adds a little action, which helps hold the students' attention. It proved helpful in courses and is often used at meetings in discussions of sire selection.

CLASSROOM PRACTICES USED IN TEACHING MEATS. P. Thos. Ziegler, *Pennsylvania State College.*

The undergraduate experience of a student has a great influence upon his ideas of good teaching practices and will be reflected in his work as a teacher. My own, somewhat unorthodox, classroom teaching methods are the result of circumvention. The present day student, through no fault of his own, places too much stress upon his grade. My first meeting with a

class is devoted to de-emphasizing grade and emphasizing the returns on the basis of personal cost. Final examinations are scheduled but seldom given. Every class period is a surprise period, in that the instructor, unknown to the student, may elect to: (1) select a student to conduct the class; (2) divide the class into two groups and pit the one group against the other; (3) have two students rise and ask one another questions alternately to determine who can outlast the class; (4) select an individual for target practice, each student asking the target a question and giving him a numerical grade; (5) give a written recitation covering one-half the period and then have the students exchange papers and grade them as the instructor gives the correct answers; (6) show a movie or slides; (7) have an identification contest on wax cuts or photographs; or (8) lecture. An examination defeats its purpose unless the student leaves the classroom with the right answers.

NEWS AND NOTES

The thirty-eighth annual meeting of the American Society of Animal Production will be held at the Hotel Sherman in Chicago on November 29 and 30, with a dinner for the honor guest on December 1. Abstracts of papers to be presented in the sectional meetings appear in this issue of the JOURNAL OF ANIMAL SCIENCE.

The Nominating Committee, composed of George A. Brown (Chairman) R. M. Bethke and G. H. Hart, has prepared the following slate of officers to be presented to the American Society of Animal Production at its next election of officers:

President, W. A. Craft
Vice-President, Paul Gerlaugh
F. A. Livesay

Ralph W. Phillips, of the Bureau of Animal Industry, attended the first meeting of the United Nations Food and Agriculture Organization's standing committee on agriculture, in Copenhagen, Denmark, beginning on August 23.

R. M. Bethke, Ohio Agricultural Experiment Station, W. A. Schoenfeld, Oregon State College, and Ralph W. Phillips, Bureau of Animal Industry, were members of a group of eight agricultural scientists that visited agricultural institutions and production areas in England, Wales, Scotland and Northern Ireland, during September and early October. Dr. Bethke and Dean Schoenfeld sailed from New York with the group on September 5, and Dr. Phillips joined them in London. This group was invited to make the trip as guests of the British Government, as a token of that government's appreciation of the help received from American agricultural workers and institutions in recent years.

Victor R. Berliner, formerly with the Lucas Farms in Fowlerville, Michigan, went to Bogota, Colombia to give a course on artificial insemination to veterinarians in the Department of Animal Husbandry of that country, for a period of three months. This work is being done under the auspices of the Office of Foreign Agricultural Relations of the United States Department of Agriculture. Upon his return to this country, Dr. Berliner will become director of the Animal Husbandry Division of the Ortho Research Foundation, Somerville, New Jersey.

Frank G. King, former head of Purdue's animal husbandry department and forced to retire in 1945, because of illness, died in LaFayette on September 5. Professor King was the Society's honor guest at its last annual meeting.

H. P. Rusk, head of the University of Illinois college of agriculture, experiment station and extension service has been granted six months recuperative leave following a major operation and hospitalization. W. E. Carroll, head of the animal husbandry department, is acting in charge during Dean Rusk's absence.

S. J. Brownell, of the animal husbandry department at Cornell University, in charge of extension, was granted a year's leave of absence effective June 1, to permit acceptance of an appointment as chief of livestock and meats in the American Military Government for Germany, with headquarters at Berlin.

Louis H. Rochford, former extension animal husbandman, University of California, is now vice-president of the Tejon Ranch Company with headquarters at Bakersfield in the same state.

By Act of Congress, the Federal Government's research relating to this raising of fur animals in pens, and domestic rabbits was transferred from the Fish and Wildlife Service of the Department of Interior to the Department of Agriculture, effective June 30, 1946. It was made

a section of the Animal Husbandry Division of the Bureau of Animal Industry, under the immediate direction of C. E. Kellogg.

C. E. Brehm, who became director of the Tennessee Agricultural Experiment Station, vice C. A. Mooers, retired, on July 1, 1946 is now acting president of the University of Tennessee. On the same date Frank S. Chance was made vice director of the experiment station and L. R. Neel retired as director of the Middle Tenn. Experiment Station. Brehm is also dean of the agricultural college and director of extension service.

Robert W. Trullinger became chief of the Office of Experiment Stations, USDA, August 1, upon the retirement of the former chief James T. Jardine. At the same time Erwin C. Elting was designated assistant chief.

B. H. Heide, secretary-manager of the International Livestock Exposition, Chicago, since its beginning, died on August 4, 1946.

N. R. Ellis, in charge of the nutrition section of the Animal Husbandry Division at the Agricultural Research Center, Beltsville, Md., was a member of a survey party of agricultural scientists that visited Alaska this past summer.

James B. Outhouse, has returned from service in the U. S. Navy to again become a member of the animal husbandry staff at the University of Maryland.

Frank Richards, a graduate of the University of Missouri and recently manager of the Kansas City Daily Drovers' Telegram, has been selected to succeed W. H. Tomhave as secretary of the American Aberdeen-Angus Breeders' Association, beginning October 1, 1946.

Walter C. Coffey, president emeritus of the University of Minnesota was presented a citation of appreciation by Gamma Sigma Delta, honor society of agriculture at the University of Illinois on May 17, 1946.

Samuel H. Work, animal husbandman for the office of Foreign Agricultural Relations, USDA, recently visited El Salvador, Guatemala and Nicaragua, Central America to assist in developing animal husbandry research in the cooperative experiment stations located in those countries.

A. D. Fitzgerald, was appointed assistant extension animal husbandman (swine) at the Louisiana State University effective July 1, 1946, succeeding R. M. Crown who was transferred to other duties.

G. Curtis Hughes, former secretary Montana Wool Growers' Association and recently released from the U. S. Navy, has been made supervisor of the Montana Wool Laboratory established at Bozeman by act of the 1945 State legislature.

T. E. Hamilton is now in full-time animal husbandry extension work at the University of Wisconsin, and has immediate charge of sow testing and swine breeding.

Vernon A. Young, former head, department of range management, University of Idaho, has joined the recently organized department of the same name in the Texas A & M College.

Marshall Hervey, after serving several years in the U. S. Army has returned to the animal husbandry staff, University of Tennessee.

Robert D. Lewis, of the Division of Cereal Crops and Diseases, BPISAE, USDA, and formerly associated with several State institutions, became director of the Texas Agricultural Experiment Station September 1, 1946.

Fred S. Wilson, superintendent of the North Montana Branch Experiment Station since 1939, has been made head of the animal husbandry department, Montana State College, succeeding R. T. Clark, who has accepted the position of coordinator of cooperative research on the improvement of beef cattle through breeding in the western region for the USDA.

Berry N. Duff, former Texas county agricultural agent and more recently with the Wool Division of USDA's P&SMA was appointed sheep and wool specialist in extension for the Colorado A & M College on July 1, 1946. Dr. Duff succeeds Gordon C. Winn, who is taking leave of absence.

Edward F. Knipling succeeded Emory C. Cushing, resigned, as head of the division of insects affecting man and animals in the USDA's Bureau of Entomology and Plant Quarantine on September 15, 1946.

Allan D. Davis, a graduate of the Oklahoma A & M College and former member of its faculty, has become a staff representative of the American Hereford Journal with headquarters at Tulsa.

Wayland Rhoads, has not returned to his civilian duties as extension animal husbandman, University of Kentucky, as stated in the last issue of the JOURNAL but has returned to Germany to again take up work with AMG.

E. L. Willett, associate animal husbandman at the Hawaii Agricultural Experiment Station has resigned to accept a position with the American Scientific Breeding Institute.

Ralph W. Jorgensen, formerly assistant professor of animal husbandry at Arizona has accepted a position as assistant animal husbandman in the Hawaii Agricultural Experiment Station.

Fred H. Leinbach, head of the Animal Husbandry Department of the University of Maryland, College Park, Maryland, has recently been appointed president of the South Dakota State College of Agriculture and Mechanic Arts, Brookings, South Dakota, and will assume his new duties on January 1, 1947.

John H. Longwell, chairman of the Animal Husbandry Department of the North Dakota Agricultural College, Fargo, North Dakota, has recently been made president of the North Dakota Agricultural College.

Marvel L. Baker, in addition to his duties in the Animal Husbandry Department at the University of Nebraska, has recently been appointed assistant director of the Agricultural Experiment Station at the same institution.

D. R. Theophilus, formerly head of the department of dairy husbandry at the University of Idaho, became dean of the College of Agriculture and director of the Experiment Station and Extension Service at the same institution on November 1.

Rufus Cox of the animal husbandry department at Kansas State College was recently awarded the degree of Doctor of Philosophy by Cornell University.

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